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NORTH AMERICAN MONOSTOMES

PRIMARILY FROM FRESH WATER HOSTS

WITH NINE PLATES AND TWO TABLES

BY

E. C. HARRAH

Contributions from the
Zoological Laboratory of the University of Illinois
under the direction of Henry B. Ward No. 208

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ZOOLOGY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS

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INTRODUCTION

The study of the Monostomata was undertaken four years ago following the suggestion of Professor Henry B. Ward, who expressed the need for a thorough study of the group. A preliminary survey of the available material served to convince me that a more complete and comparative study of the group was desirable and that such a study would prove of value to helminthologists. This study seemed more desirable since but two comparative studies of the group had been made in the last twenty-five years. The first of these was that of Stossich (1902) which is based wholly on European material; the second that of Kossack (1911) is based largely on the same material. The fact that very little had been done on this group in America and that no comparative study of the American fauna had been undertaken furnished further incentive for this work.

The writer undertook an investigation of the group which should be comprehensive in scope and at the same time comparative. For this purpose he had free and unlimited use of the large personal collections of Professor Ward secured thru extensive field work as well as obtained by exchange. These had been augmented, with a view to getting a complete series, by loans of material from European and American investigators. Unfortunately specimens of certain originals could not be secured either because they had been lost or because they could not be removed from the collections.

Thanks are due to the following investigators who at the request of Professor Ward kindly sent material from valuable collections for study and comparison; Professor Anton Collin, University of Berlin; Professor Theodor Pintner, University of Vienna; the curator of the Museum, University of Göttingen; Professor Fr. Zschokke, University of Basel; Dr. C. W. Stiles, Hygienic Laboratory, Washington, D. C.; Dr. B. H. Ransom, Bureau of Animal Industry. Dr. John C. Johnson has also very kindly loaned the writer material for study. For the study of *Cyclocoelum halli* and *Cyclocoelum wilsoni*, use has been made of the field notes of W. C. Hall filed with the records of that series.

Especially to Professor Henry B. Ward under whose supervision the work has been done, the writer desires to express most sincere thanks for the use of his extensive collections and of his library, as well as for his efforts to secure rare material and for the continued deep interest and hearty cooperation which have given the inspiration to finish this work.

METHODS OF INVESTIGATION

The methods employed in this study are those ordinarily used with similar material. No special technique has been found necessary. In general sections were stained in toto with Erlich's acid hematoxylin and counterstained in section with alcoholic eosin. Sections were cut 10 to 20 micra in thickness. Frontal, sagittal, and transverse sections were used. In order to obtain a clearer perception of more minute and obscured parts wax reconstructions were made. These were employed particularly to find the relationship and constancy of form of the female genital organs.

MATERIAL

The material on which this study is based is composed of various collections from different regions of the United States. It is limited to that obtained from North American fresh water hosts and in each instance is listed with the species description. However for comparison with the Amerian material the following specimens were secured from the sources indicated.

EUROPEAN MATERIAL

From the Zoological Museum, Berlin

Species	*Host*	*Cat. No.*	*Collector*
Cyclocoelum problematicum	*Totanus glottis*	2449	Ehrenberg
Cyclocoelum problematicum	*Totanus glottis*	2455	Ehrenberg
Cyclocoelum problematicum	*Canis vulpecula*	2454	Ehrenberg
Cyclocoelum ovopunctatum		1342	
Cyclocoelum brazilianum	*Scolapax flavicepa*	2494	v. Olfers
Cyclocoelum tringae		2495	Ehrenberg
Haematotrephus similis	*Himantop. atropterus*	2486	Ehrenberg
Haematotrephus similis		2309	Ehrenberg
Monostomum vanelli	*Vanellus cristatus*	1326	Rudolphi

From the Zoological Museum, University of Göttingen

Cyclocoelum (*Monostomum*) *mutabile* (Zed.)	*Gallinula chloropus* Taken at Claustal	284	Mehlis
Monostomum verrucosum	*Anas bernicla*	234	Mehlis
Monostomum attenuatum	*Mergus merganser*	238	Mehlis
Monostomum attenuatum	*Anas fuligula*	220	Mehlis

From the Zoological Museum, University of Vienna

Monostomum mutabile	*Totanus flaviceps* Taken in Brazil	IX 552	

From the Collection of Henry B. Ward, University of Illinois

Collyriclum faba	*Passer domesticus* Taken in Switzerland	21.764	Zschokke

NORTH AMERICAN MATERIAL

From the Leidy Collection

Cyclocoelum leidyi (*Monostomum mutabile* Zeder of Leidy)	*Gallinago wilsoni*	160	Leidy

Species	*Host*	*Cat. No.*	*Collector*
Cyclocoelum pseudomicrostomum (*Monostomum mutabile* Zeder of Leidy)	*Fulica americana*	186	Leidy
	From the collection of the Army Medical Museum		
Cyclocoelum obscurum	Stereolepsis sp?	1035	Leidy
	From the collection of the Bureau of Animal Industry		
Notocotylus urbanensis (*Monostoma* sp. Stiles & Hassall)	*Dafila acuta*	5772	Stiles & Hassall
Notocotylus urbanensis (*Monostoma* sp. Stiles & Hassall)	*Fiber zibethicus*	5769 5770	Stiles & Hassall
Notocotylus urbanensis (*Monostoma* sp. Stiles & Hassall)	*Aix sponsa*	5771	Stiles & Hassall
Notocotylus quinqueserialis (*Monostoma* sp. Stiles & Hassall)	*Arvicola riparius*	5773	Stiles & Hassall
	From the Collection of Henry B. Ward, University of Illinois		
Cyclocoelum pseudomicrostomum	Wild duck	10.41	
Cyclocoelum cuneatum	*Gallinago delicata*	08.172	
Cyclocoelum obscurum	*Symphaemia semipalmata*	08.179	
Cyclocoelum obscurum	(unknown)	08.183	
Cyclocoelum macrorchis	Straight billed curlew	08.180	
Notocotylus quinqueserialis	*Fiber zibethicus*	15.120	
Paramonostomum echinum	*Fiber zibethicus*	21.91	
Heronimus chelydrae	Snapping turtle	08.176	
	Emys blandingi	12.161, 162, 163	
	Chrysemys marginata	N.B. 15, 21.760, 22.169	
	Kinosternon odoratus	16.425	
	Cinosternum pennsylvanicum	22.40, 41	
	Graptemys geographicus	22.166	
Collyriclum colei	*Passer domesticus*	11.11	L. J. Cole
		11.12, 21.961, 762	
Cyclocoelum halli	*Totanus melanoleucus*	21.90	W. C. Hall
	Totanus solitarius	21.763	W. C. Hall
Cyclocoelum wilsoni	*Gallinago delicata*	21.89	W. C. Hall
Cyclocoelum triangularum	*Tringa maculata*	21.88	W. C. Hall

HISTORICAL DATA

More than a century ago the first of the Monostomata were described. Since that time many helminthologists have contributed to the study of this group. Most notable of the older authors are Zeder, Rudolphi, von Siebold, Van Beneden and Diesing. In more recent times Brandes, Stossich, Looss, Lühe, Monticelli, Kossack and Odhner have contributed materially to our knowledge of the European forms.

Apart from the work of Goeze (1782) who described two species which he believed to have only one sucker and that of Schrank (1788) which was a mere catalogue of species, Zeder (1800, 1803) was the first to establish this group. In 1800 he created the genus Monostoma based on five species; *Monostoma ocreatum*, and *Monostoma bombynae* which have since been removed to the distomes; *Monostoma verrucosum* a Notocotylid; and *Monostoma prismaticum* and *Monostoma mutabile* which are now transferred to the genus Cyclocoelum. Rudolphi in his Synopsis Entozoorum served in the early organization of the group. While a number of species were imperfectly known at this time it was not until the work of von Siebold (1835) was published that the anatomy of these worms was clearly understood. In this work the author gave a good description of *Monostoma mutabile* Zeder along with the early stages of the life history as shown in the development of the egg before it is discharged from the uterus. Diesing (1850) reorganized the genus including all species described up to this time. Following this Van Beneden (1861) reviewed the anatomy of *Monostomum mutabile* and added a description of the anatomy of *Monostomum verrucosum* Frölich with a study and description of a cercaria which he believed to be the larval form of this species. The next important contributions to the knowledge of this group were those of Monticelli (1892) in which he gave a complete account of the genus Notocotyle Diesing and in a second paper in the same year a similar account of *Monostomum cymbium* Diesing. Closely following these was the Revision of Brandes (1892) in which he proposed the new genus Cyclocoelum to include *Monostomum mutabile*, *M. flavum*, *M. arcuatum*, *M. tringae* and *M. ellipticum*.

In more recent time the work of Stossich (1902), Odhner (1905, 1907) and Kossack (1911) stands out as important contributions to the knowledge of this group. Looss and Lühe have likewise had a share in the organization of the group as a unit. The most recent European work on members of this group is that of Jegen (1917) in which he presents data on the life history and relationship of *Collyriclum faba* Bremser.

In North America little has been done on this group of trematodes and aside from the systematic arrangement of species by Pratt (1902) and the descriptive key of Ward (1918) only isolated descriptions of species have appeared. The earliest report of species which have been assigned to this group are those of Joseph Leidy (1856–1895) the descriptions of which are so meager that some of the forms must remain as species inquirendae.

MacCallum (1902) found and described *Heronimus chelydrae* from the lungs of the snapping turtle. Barker and Parsons fifteen years later redescribed this form without reference to the work of MacCallum under the name *Aorchis extensus*. Barker and Laughlin (1911) described *Notocotyle quinqueserialis* from the intestine of *Fiber zibethicus* and later Barker (1916) described from the same host the new genus and species *Nudocotyle novicia*. These with the report by Cole of *Monostoma faba* (later named *Collyricum colei* by Ward) are the major items from North America. More recently Stunkard (1919) has shown that *Heronimus chelydrae* of MacCallum and *Aorchis extensus* of Barker and Parsons are identical, and Tyzzer (1918) from the study of *Collyriclum colei* Ward and comparison of it with the description of *Collyriclum faba* Bremser by Kossack, provisionally regards them as identical. Tyzzer's paper affords a detailed account of the anatomy of this species and a study of the maturation, fertilization and development of the miracidia within the eggs. His views regarding the identity of the two forms are discussed in detail later (p. 62–65).

SPECIES PREVIOUSLY DESCRIBED FROM NORTH AMERICA

Most descriptions of North American species of this group are inadequate and as a result of this it is impossible to determine with any degree of accuracy their rightful systematic position without re-examination of the material. This has been lost in a number of cases and in other instances all effort to locate certain specimens has proved futile. The following list is an attempt to bring together all references to date on the species previously described from North American fresh water hosts. Names indented represent later descriptions of the same form arranged in chronological order.

Monostomum ornatum Leidy 1856:43
    Monostomum ornatum Brandes 1892:504–510
    Haematoloechus? Stafford 1902:724

Monostomum incommodum Leidy 1856:43
    Distoma oricola Leidy 1884:47
    Distoma oricola Leidy 1891:414

Monostomum affine Leidy 1858:43
    Notocotyle? affine (Leidy 1858) Barker 1916:183

Monostomum spatulatum Leidy 1858:111
Monostomum spathulatum Leidy of Diesing 1859:426

Monostomum asperum Vaillant (nec. Nitzsch) 1863:6–7; 1863:347–348
Monostomulum asperum Vaill. of Brandes 1892:504–511
Monostomum aspersum Vaill. of Pratt 1902:966
Monostomum aspersum Vaill. of Pratt, Ward 1918:382

Monostomum mutabile Zeder of Leidy 1885:9
Cycloccelum leidyi nov. spec. of this paper

Monostomum obscurum Leidy 1887:24
Cyclocoelum obscurum (Leidy) of this paper

Monostomum amiuri Stafford 1900:402

Cyclocoelum vicarium (Arnsdorff 1908) Kossack 1911:518
Monostomum vicarium Arnsdorff 1908:362

Notocotyle quinqueserialis Barker and Laughlin 1911:261–274

Catatropis filamentis Barker 1915: Pl. I, fig. 6
Catatropis fimbriata Barker 1915:190

Nudocotyle novicia Barker 1916:175–184

Heronimus chelydrae MacCallum 1902:632–636
Aorchis extensus Barker and Parsons 1914:193–194

Collyriclum colei Ward 1917:2–3
Monostoma faba Cole 1911:42–48
Collyriclum faba Tyzzer 1918:267–292

NEW SPECIES DESCRIBED IN THIS PAPER

Cyclocoelidae
Cyclocoelinae
Cyclocoelum leidyi nov. spec.
Cyclocoelum pseudomicrostomum nov. spec.
Cyclocoelum macrorchis nov. spec.
Cyclocoelum wilsoni nov. spec.
Cyclocoelum halli nov. spec.
Cyclocoelum triangularum nov. spec.
Cyclocoelum cuneatum nov. spec.
Notocotylidae
Notocotylinae
Notocotylus urbanensis (Cort)
(Cercaria only known previously)
Paramonostomum echinum nov. spec.

FAMILIES OF MONOSTOMIDAE

Altho in another section of this paper the monostomes are shown to be more closely related to other groups than to each other it is thought best to preserve the group classification until further evidence is secured which definitely proves the suggested relationship. For this reason the key to the monostome families is included and it is expected to serve only for the rapid determination of specimens rather than to furnish full diagnostic characters.

KEY TO FAMILIES

1(2) Intestinal crura anastomosing in the posterior end.....
.....Family Cyclocoelidae
2(1) Intestinal crura ending blindly near the posterior end.....3
3(4) Testes lateral to crura.....Family Notocotylidae
4(3) Testes within crura.....5
5(6) Excretory pore posterior and terminal....Family Collyriclidae
6(5) Excretory pore dorsal; in anterior body half. Family Heronimidae

DESCRIPTION OF FAMILIES

Validity of the older name.—The question raised by Lühe (1901) regarding the use by Looss (1899) of the family name Monostomidae Cobbold 1866 [erroneously credited to Monticelli by Lühe (1901) and by Stossich (1902)] without a type genus Monostomum and the extended discussion of Looss (1902) is a needless one if the rules of the International Code be applied. Article V of this code deals specifically with the family name which by the acceptance of the genus name Cyclocoelum becomes Cyclocoelidae.

CYCLOCOELIDAE Kossack 1911

Diagnosis.—Endoparasitic trematodes of large to middle sized muscular bodies. Mouth opening terminal or subterminal surrounded by muscular sucker usually much reduced. Ventral acetabulum sometimes present, pharynx large, muscular; esophagus long. Intestinal crura simple or possessing internal ceca, anastomosing in the posterior end of the body. Excretory bladder between posterior intestinal arch and end of body with median dorso-terminal pore. Genital pore median, usually ventral to pharynx. Copulation organs present, well developed; seminal vesicle in cirrus pouch. Vitellaria in general lying between body wall and intestinal crura, sometimes surrounding the latter. Genital glands between intestinal crura, simple or lobed, forming the points of a triangle. Laurer's canal wanting; receptaculum seminis present. Uterus strongly developed lying in more or less regular folds between intestinal crura over which they sometimes extend, usually filling entire space between crura. Eggs numerous, without polar filament, usually containing well developed miracidia with characteristic double eye spots.

Parasitic in body cavity, lungs and nasal cavities of water birds.

Type and only American genus Cyclocoelum. Other genera Haematotrephus, Hyptiasmus, Typhlocoelum, Tracheophilus, Ophthalmophagus, Spaniometra and Bothriogaster.

The foregoing diagnosis differs from that of Kossack in noting that an oral sucker and a receptaculum seminis have been found in two genera of this family, namely Cyclocoelum and Haematotrephus. In the genus Cyclocoelum these organs have been found in the species described in this paper as well as in the following European species: *Cyclocoelum problematicum* Stoss., *Cyclocoelum ovopunctatum* Stoss., *Cyclocoelum brazilianum* Stoss., and in *Cyclocoelum tringae* (Brandes) as well as in *Haematotrephus similis* Stoss.

During the study of the Cyclocoelidae and the attempt to prepare a key the writer was impressed with the segregation of the genera into distinct groups. These groups are here designated as sub-families. The group composed of Cyclocoelum, Haematotrephus and Hyptiasmus are according to this grouping left in the sub-family Cyclocoelinae created by Stossich (1902) for the entire group. A second group is that formed by Typhlocoelum Stossich and Tracheophilus Skrjabin (1913) which on the basis of the strongly developed vitellaria and diverticula of the intestine deserve rank as a distinct sub-family to which I desire to assign the name Typhlocoelinae. As stated in a later section of this paper Cohn (1904) would ally this group with the Fasciolidae on the basis of a rudimentary sucker found in *Typhlocoelum flavum* (Mehlis). A third group is that formed by Ophthalmophagus and Spaniometra and is based on the position of the ovary in the intestinal arch with the testes anterior thereto, and on the position of the vitellaria which in these genera are ventral to the intestine. Bothriogaster is also placed in this group although it presents some striking differences, especially with respect to the vitellaria which in this genus are markedly like those of Cyclocoelum. However with respect to the reproductive glands it conforms more nearly to Spaniometra. Other peculiarities of this genus will be discussed elsewhere in this paper.

KEY TO SUB-FAMILIES AND GENERA

1(11) Ovary between testes or on a level with posterior testis.....2
2(8) Intestinal crura without diverticula.....
.....Sub-family Cyclocoelinae Stossich 1902....3
3(6) Right and left sides of vitellaria separated at posterior end....4
4(5) Uterus loosely folded; long loops surrounding genital glands....
.....Haematotrephus Stossich 1902
5(4) Uterus compact; loops short not surrounding genital glands....
.....Cyclocoelum Stossich 1902
6(3) Right and left sides of vitellaria continuing into one another at posterior end.....7
7 Uterine loops extending laterally over intestinal crura and vitellaria to body wall.....Hyptiasmus Kossack 1911
8(2) Intestinal crura with distinct diverticula.....
.....Sub-family Typhlocoeline 9
9(10) Testes strongly lobed.....Typhlocoelum Stossich 1902
10(9) Testes round.....Tracheophilus Skrjabin 1913
11(1) Ovary posterior to testes, situated in intestinal arch.....
.....Sub-family Ophthalmophaginae 12
12(15) Vitellaria ventral to crura.....13
13(14) Testes in posterior body half.Ophthalmophagus Stossich 1902
14(13) Testes in anterior body half.....Spaniometra Kossack 1911

15(12) Vitellaria lateral to crura.....
Ventral acetabulum conspicuously developed.....
.....Bothriogaster Fuhrman 1904

Up to the present the only genus in this family represented in North America is Cyclocoelum and for this reason the other genera are not dealt with in the following pages.

CYCLOCOELUM

Historical.—The question of the type for this genus is indeed a complicated one and as Stiles (1908) has said "well represents a ship without a rudder." Lühe accepts the designation of Hoyle (1888) and takes issue with Looss who by elimination accepts *Monostomum prismaticum* as type. Stiles (1908) presents a third view in which he says that the name Monostomum is a synonym to Festucaria by priority rule, since Zeder deliberately renamed the genus Festucaria Schrank (1788).

A critical study of the literature involved brings to light certain facts on this point which seem to the writer to be worthy of space here. The name Festucaria was proposed by Schrank (1788) for two species *Festucaria anatis* and *Festucaria strigis*. These species were described by Goeze (1782) in Klasse II of his family (genus) Planaria as "rundlichte oder walzenförmige Plattwurm" of which he says there are two genera. Only one of them is of concern here and is described by Goeze (1782:173–174) as having a single mouth, ("mit einfacher Mündung").

From the context of the description one is led to believe that these worms were collected by Goeze since he says, "Ich, * * * habe sie nur in zwo Arten von Vogeln gefunden; in einer zahmen Ente, und in einer grauen Weideneule." He follows this with a description of the worms in situ as well as when he placed the intestine of the host in water where the worms "loosed themselves."

The type of the genus Festucaria becomes by page precedence *Festucaria anatis* Schrank (1788). This purports to be the same worm described by Goeze (1782:174) as follows:—"In den Dedärmen einer Ente sassen hin und wieder kleine gelbliche Knötgen. Da ich einige abnehmen wollte, merkte ich, dass sie vest anklebten. Als ich sie ins Wasser brachte, gaben sie sich los, und ich erkannte sie für rundlichte Plattwürmer mit einer Mündung." The description of his figure 9 plate 13 adds "(a) die einfache Mündung mit 2 Punkten; (b) eine Art von Maul darüber." From the description and the figures this appears to be the crown of spines which Goeze mistook for a mouth.

The description of Schrank (1788), based on Goeze (1782), runs as follows:—

Splitterwurm—Festucaria

Ein länglichter, einförmiger Würm vorne mit einer einzigen Saugemündung.

"Enten Sp. 54, Cylindri-formed, columnar, wälzenformig." "Zween erhabene Punkte in der Mundöffnung, *Festucaria anatis*." "Goeze Eingew. 174 tab. 13, figs. 8–11; in Enten."

Gmelin (1790) classifies the same worm as *Fasciola anatis*. Zeder (1800) renames the genus Festucaria, Monostoma, and includes under the name the following species;

Monostoma elaphi
Monostoma prismaticum
Monostoma ocreatum
Monostoma mutabile
Monostoma verrucosum
Monostoma bombynae

In the same work the species of Schrank (*Festucaria anatis*) (Fasciola of Gmelin) is described as an Echinostome (*Distoma anatis*). Rudolphi (1801) recognized the same genus Festucaria Schrank with Monostoma Zeder as a synonym and later in the same paper (p. 62) stated that he permits the name Festucaria to stand even though Zeder had proposed a new one. This name he retained until 1809 when he rejects it for the denomination of Zeder which he says "omnino praeferenda sit." In his later paper (1819) Rudolphi still adhered to the genus name of Zeder. Subsequent to this time helminthologists have accepted without comment the genus Monostoma of Zeder. Consequently Hoyle (1888) de ignated *Monostoma mutabile* as type of this genus. Four years later Brandes (1892) in his Revision der Monostomiden grouped together what he believed to be members of this genus, "als gute Arten," *Monostoma mutabile* Zeder, *M. flavum* Mehlis, *M. arcuatum* Brandes, *M. tringae* Brandes and *M. ellipticum* Rudolphi and suggested their separation from the remaining species under the name Cyclocoelum with the following diagnosis: "Diese fünf Spezies scheinen ihrer Organisation und Lebensweise nach zusammenzugehören, jedenfalls die ersten 4, die sämmtlich in der Leibes- oder Infraorbital-höhle von Wasservögeln schmarotzen, während *M. ellipticum* in der Lunge von *Rana maculata* gefunden wurde, * * * . Die Enden der Darmschenkel mit einander verschmelzen, sodass der Darmtractus einem Ring darstellt." Looss (1899) accepted the revision of Brandes and named *M. mutabile* as type of the genus of Brandes. Later in the same notable work the author used the term Monostomidae to characterize a certain group of worms. But his contemporary Lühe (1900) in a review of the work of Looss objected on the ground of the nomenclature law to the use of the family name Monostomidae without a type genus Monostoma and called attention to the priority of the "völlig verschollenen" genus Festucaria Schrank. One year later Looss (1901) in explanation and confirmation of his earlier work showed by elimination that *Monostomum prismaticum* is type of the genus Monostoma Zeder. In regard to

the right of priority of Festucaria Schrank he stated that he found no reason to call back from oblivion that absolutely meaningless name. "Ich habe mich bisher nicht veranlasst gefühlt, diesen auch mir bekannten, aber in der That gänzlich der Vergessenheit anheimgefallenen und praktisch absolut bedeutungslosen Namen wieder ins Leben zurückzurufen; ich empfinde dafür auch heute noch keine Neigung und überlasse deshalb die Entscheidung der Frage mit Vergnügen denjenigen, die sich mehr dafür interessieren." Lühe continued the discussion on the basis of the priority of Festucaria Schrank and the deliberate renaming of Zeder. He stated, however, that he believes *Festucaria anatis* Schrank (based on Goeze 1782, Taf. 13, Figs. 8–11) to be *Echinostomum echinatum*. However Lühe continued to use the genus name Monostoma Zeder.

Stossich (1902) accepted *Monostoma mutabile* Zeder (1800) as the earliest record of the group and approved its removal by Brandes (1892) to the genus Cyclocoelum. He does not consider the priority of Festucaria or the renaming by Zeder (1800) but Zeder says distinctly that Schrank (1788) placed those worms with one sucker in a genus under the name Festucaria and that he (Zeder) in conformance to the German system of nomenclature wished to introduce the Greek term Monostoma which he considered a more appropriate and characteristic name.

Kossack (1911) cited the positions of Hoyle, Lühe, Looss and Stiles previously mentioned; he then avoids the real situation by accepting only the more generally recognized works and thus believes himself dealing with a necessity, and also to be in full accord with the law of priority. On this basis he omits from the discussion the genus name Festucaria and substitutes for the old name Monostoma the more significant name Cyclocoelum.

It seems to the writer that the case at hand is clearly covered by Article 32 of the International Rules of Zoological Nomenclature; and after a careful study of the case the writer is led to accept Stiles' view and to abide by the ruling of the International Commission according to which the genus Monostoma Zeder (1800) becomes a synonym of Festucaria Schrank (1788). The fact that Zeder did not include the original species, *Festucaria anatis*, in his genus does not affect the case since the genus name would remain with the type species; hence the redescribing of this form by Zeder under the name *Distoma anatis* does not change the case since in that event Festucaria falls with Monostoma into synonomy. Then *Festucaria strigis* having been removed to the genus Strigea, whether *Festucaria anatis*, is a distome (Zeder 1800), or an echinostome (Zeder 1803, Rudolphi 1809, and Lühe 1901), the case remains the same and can be analyzed only as a direct renaming of the original form. Accordingly the species of Monostoma Zeder fall in the genus Festucaria Schrank 1788. The type is clearly *Festucaria anatis*.

The opinion expressed by Lühe (1901) that he believes *Festucaria anatis* to be an echinostome, is indeed not a new view for in fact it is suggested in the description of Goeze when he describes the orifice as having above it a sort of a mouth. As was mentioned earlier in this work Goeze probably erroneously described the crown or ring of spines for the mouth. Also his description of the worms in situ in the intestine of a domestic duck suggests the probability of an echinostome. Zeder (1800) evidently recognized the distome nature of these worms for he described in his group Echinis under the name *Distoma anatis* worms which he terms identical with *Cucullanus conoideus* Bloch (1782), *Planaria enten* sp. Goeze (1782), *Festucaria anatis* Schrank (1788) and *Fasciola anatis* Gmelin (1790). Characteristic points of his description are the large acetabulum and the ring-like swelling around the head armed with spines. In 1803 this worm was described by the same author as *Distoma echinatum*. Rudolphi (1809) described *Cucullanus conoideus* Bloch, Planaria (teres poro simplici) Goeze, *Fasciola anatis* Gmelin, *Festucaria anatis* Schrank, *Distoma anatis* Zeder (1800) and *Distoma echinatum* Zeder (1803) as identical. Likewise Diesing (1850) and Baird (1853) interpret *Festucaria anatis* as identical with *Distoma echinatum*. This with the opinion of Lühe already given appears to be sufficient evidence to determine the probably Echinostome nature of *Festucaria anatis* Schrank. In any event the species described by Zeder (1800) as *Monostoma mutabile* which we now know as *Cyclocoelum mutabile* is quite strikingly different anatomically and hence clearly not closely related to *Festucaria anatis* based on the opinions of Zeder (1800, 1803), Rudolphi (1809, 1819), and Lühe (1901). From a study of the literature the writer is in agreement with the opinion of Lühe, Rudolphi and Zeder that *Festucaria anatis* is probably *Echinostomum echinatum* Rud. (1809). Whether these authors studied the same material can be only a matter of conjecture.

An additional fact, however, is furnished by our present knowledge of the normal habitat of these worms which with few exceptions are confined to partially closed cavities of the body, the infraorbital sinus, and areal sacs for Cyclocoelum and Hyptiasmus, and the trachea for Typhlocoelum. As has been previously noted the habitat of *Festucaria anatis* is the intestine of a domestic duck.

The genus Cyclocoelum Brandes (1892) was formulated to include the following species *Monostoma mutabile*, *M. flavum*, *M. arcuatum*, *M. tringae*, and *M. ellipticum* with the following description: first four species collected from the body cavity and infraorbital sinus of water birds the fifth *Monostoma ellipticum*, from the lungs of *Rana maculata*, with intestinal crura anastomosing in the posterior end.

In the acceptance of the genus name Cyclocoelum Brandes (1892) the writer realizes that he is subject to criticism on account of the genus

Cyclocoela Dujardin (1845) and in view of this fact calls attention to the recommendation of the International Zoological Commission in the International Code which reads:—"It is well to avoid the introduction of new generic names which differ from generic names already in use only in termination or in a slight variation in spelling which might lead to confusion. But once introduced, such names are not to be rejected on this account."

Structure of the Genus

The description of Stossich (1902) states that these worms are covered with spines which that author interprets of sufficient importance to be a specific characteristic. Although Zeder (1803) observed these granulations he was not able to determine their real nature and suggests that they are either cellular structures or glands underlying the thin cuticula. It was not until the work of Fuhrmann (1904) was published that the true nature of these, which are really pits became known. This author described and figured these pits as found on the ventral surface of *Bothriogaster variolaris* and stated that he has observed similar depressions on both the dorsum and venter of *Cyclocoelum mutabile*. However, he raises the question whether these are not a product of preservation. Kossack (1911) verified the work of Fuhrmann by similar observations on several species belonging to at least three distinct genera of this family. He supported the view of Fuhrmann as to their origin and added as evidence of their nonexistence in living material that the authors who had opportunity to study living material—notably von Siebold and Van Beneden—did not mention their presence.

There can be no doubt that Zeder (1800, probably also 1803) made observations on living material. That the particular observation mentioned above was made from living material of course is only a matter of conjecture. It is evident, however, that at least one author who studied living material did observe these pits. Hence the lack of mention by von Siebold and Van Beneden is not sufficient evidence to prove their nonexistence in living material.

That the state of contraction at the time of fixation is responsible for the degree of depth and apparent frequency of these pits remains unquestioned. But unless they occur in the living specimen it would be impossible to find them so regularly in preserved material. In addition if they are artifacts of preservation one would expect to find them in other trematides of similar size and structure.

While the writer has not had opportunity to study living Cyclocoelidae he has found the above mentioned "Grübchen" of Kossack, the "ovale depressionen" of Fuhrmann, constantly in more than one hundred and fifty specimens belonging to at least nine species of the genus Cyclocoelum and in *Haematotrephus similis*. While in the study of more than a hundred

specimens of *Heronimus chelydrae* MacCallum (1902) both living and preserved not a single instance has been found. For these reasons the writer feels safe in saying that these pits are characteristic of the living animal and are only emphasized by the state of contraction at the time of preservation. The various worms being fixed in different states of contraction would consequently show these pits more conspicuously in the more contracted specimens.

The body wall is composed of at least five layers. From outside inward they are as follows, cuticula, basement membrane, circular muscle, longitudinal muscle, and epithelium (Fig. 25). These compose what is commonly known as the dermomuscular sac. The disposition of the parts of the dermomuscular sac of this group agrees in most respects with the interpretation of Monticelli (1888) and Blochmann (1896). It differs however from the observation of Fuhrmann (1904) in which he says that the body musculature is differentiated into outer longitudinal, inner circular muscle layers and inside of this the layer of bands of diagonal muscles, in that the outer muscle layer is formed by circular muscles (Fig. 25). The single statement of Fuhrmann mentioned above is so strikingly different from all comprehensive works on this subject that the writer is lead to believe that it is a *lapsus calami* and that in reality the muscle layers of *Bothriogaster variolaris* are identical with those of other trematodes.

Zeder (1803) states that these worms have a single sucker on the forward end. His description of this organ is scanty and lacks the points which distinguish the sucker from the pharynx so that one is lead to believe in the light of present knowledge that he interpreted the pharynx in the Cyclocoelidae to be the same as the sucker in the Notocotylidae. Von Siebold (1835), the first to give a clear account of the anatomy of the Monostomidae in his description of *Cyclocoelum* (*Monostomum*) *mutabile* (Zeder), speaks of the mouth as a transverse oral opening leading to a funnel shaped canal which narrows gradually posteriorly and terminates in the so-called pharynx. No trace of a sucking organ was observed by this author.

Following this Van Beneden (1858) referred to the above work frequently but stated that the monostomes have only a mouth sucker situated in the anterior region. In another paragraph of the same work he speaks of the digestive system of Trematodes as showing generally an anterior sucker in the bottom of which is situated the mouth. This he says opens into a second enlargement similar to the preceding sucker, the pharyngeal bulb. In his figures of *Cyclocoelum* (*Monostomum*) *mutabile* (Zeder) the structure termed pharyngeal bulb above is indexed as buccal bulb. These show the pharyngeal bulb with no anterior sucking musculature surrounding the mouth opening. In a later paper (1861) the same author describing again this same species spoke of the bulb and the region preceding it which

he said is seen with difficulty. A little later in this work in the description of *Notocotyle* (*Monostomum*) *verrucosum* he employed the term "la ventuose antérieure ou plutôt le buccal," applying it to the spherical muscular bulb at the extreme anterior of this worm a Notocotylid, evidently mistaking this structure for the same structure termed the pharyngeal bulb in the earlier work. His descriptions show clearly that the same organ which in the distomes is termed pharynx is here termed anterior sucker or buccal bulb.

Some years later Monticelli (1892) described the mouth as small in *Monostomum mutabile* and *Monostomum expansum;* of greater or less size in *Ogmogaster plicatum* and *Monostomum galeatum;* circular in *Monostomum hippocrepis* and *Monostomum trigonocephalum;* ellipsoidal in *Monostomum cymbium* and *Monostomum ornatum.* It is usually ventral and generally situated in the extreme anterior end. When present a prepharynx of variable length is situated directly in front of the pharyngeal sucker, the "anterior sucker or buccal bulb" of Van Beneden. Monticelli thus distinguishes between the funnel shaped tapering canal of von Siebold (1835) and the adjoining posterior structure; and designates it as a prepharynx. He says that in Notocotyle and some other genera of this family the prepharynx is wanting and that then the pharynx is anterior and plays the rôle of an anterior sucker. For this reason he designates this structure in these genera as a sucker pharynx.

Braun one year later, refers to the description of Monticelli and suggests that a sucking organ has been developed out of the pharynx. In 1901 the same author refers to the "bulbus buccalis" of Van Beneden, or pharynx of Monticelli, as a Mundsaugnapf which he says is followed by the esophagus. In another paragraph of the same work when describing *Monostomum trigonocephalum* Rud. (since removed to the genus Pronocephalus by Looss) collected from the intestine of the sea turtle he says that the sucker is 0.12 mm long and 0.09 mm broad and again states that it is followed by a straight esophagus 0.3 mm long, without a pharynx. Thus Braun has construed the muscular structure at the extreme anterior in the Notocotylidae, Pronocephalidae and other families of this group to be a development of a structure similar to that termed pharynx by Monticelli in the Cyclocoelidae.

Barker and Laughlin (1911) accept this view without comment and describe the worms *Notocotyle quinqueserialis* as clinging to the intestine of the muskrat tenaciously with the well developed oral sucker. They found no evidence of a pharynx.

Taschenberg (1879) describes the mouth in the genus Didymozoon as an opening followed by a funnel shaped duct leading to the pharynx. This he states to be generally characteristic of the entire group. Lönnberg (1891) found in *Didymozoon lampridis* the well developed sucker (pharynx of

Taschenberg) and just posterior to it a very small muscular bulb the pharynx. Odhner (1907) finds in *Didymozoon scombri* Tschbg. a similar pharyngeal bulb which he figures and proves beyond doubt that the pharynx of Taschenberg is a very strongly developed sucker followed by an extremely small pharynx. In this same notable work he says that in *Cyclocoelum* (*Monostomum*) *mutabile* (Zeder) and other parasites where only a pharynx is present that there is always a region anterior to it which he terms the "Mundrohr" or "Mundhöhle" (prepharynx of Monticelli), a structure which by the contraction of the inner walls changes the pharynx into a sucker. This same region is shown in the figures of Odhner for *Didymozoon scombri* Tschbg.

Looss (1899) speaks of the mouth sucker but gives no equivalent for the pharynx of Monticelli. Later, however, he interprets the swelling at the beginning of the esophagus in *Microscapha reticularis* as a pharynx. Cohn (1904) calls this to account when he states that this swelling is nothing more than the esophageal sphincter which is present in many species. The same author interprets the oral sucker of Looss, or buccal bulb (anterior sucker) of Van Beneden, as a pharynx and adds that it is his opinion that soon monostomes will be found with a well formed sucker adjoining a typical pharynx. The evidence given in support of this consists of the statement that *Haplorchis cahirinus* Looss has a strongly developed pharynx preceded by a rudimentary sucker and that he has observed in *Cyclocoelum* (*Monostomum*) *mutabile* (Zeder) and in one other species (to be published later) a rudimentary sucker. On the contrary Looss (1899) figures *Haplorchis cahirinus* with a well developed but small oral sucker followed by a somewhat smaller but perfectly developed pharynx and in his description of this species states specifically that the oral sucker and the pharynx are well developed structures. He regards the rudimentary structure occurring on the ventral side as an acetabulum. He adds also that the nerve commissure which according to Braun lies in all the Digenea more or less bent around the dorsal side of the oral acetabulum and the pharynx, is in front of the muscular sucking organ in the Monostomidae and therefore that organ is a true pharynx, tho this organ serves both as a sucker and a pharynx.

Stossich (1902) calls the pharynx of Monticelli an "inner sucker" which he says serves the same function as the mouth sucker of other trematodes.

Odhner (1907) states that those that acquire holdfast organs in the least degree are the parasites of the respiratory organs; the group containing *Cyclocoelum mutabile* being entirely suckerless. Kossack following the decision of Monticelli says that the question can be determined only by a study of the position and distribution of the nerve ganglia. Consequently he termed the anterior muscular structure a true pharynx. Ward (1918) calls the same structure the oral sucker and says that no pharynx is

present. The interpretation of Braun, Looss, Ward and others is indeed well exemplified in many cases where the anterior region is telescoped posteriad over the opened anterior portion of the pharynx (Fig. 46).

Records of an oral sucker in this group are few, aside from that found in *Cyclocoelum mutabile* by Cohn (1902). Wedl (1857) gives an account of the oral sucker in *Monostomum lanceolatum* as follows:—"Der kleine Mundnapf liegt an der Bauchseite des zugeschmälerten Vordertheiles des Thieres (Fig. 15a) und ist nach rückwärts von einem dickfleischigen *Bulbus oesophagus* (b) begrenzt, * * * ". These with the account of the writer (Harrah 1921) in which the oral sucker was described in two species of this genus constitute the evidence produced to demonstrate the presence of the oral sucker in this group.

In the light of the foregoing the question brought out by a long continued controversy remains unsettled. Is the structure termed the pharynx by Monticelli (1892) phylogenetically a pharynx or an oral sucker? While Monticelli attempted to prove by the distribution of the anterior nerves that the muscular bulb, or pharynx as he termed it, was a true pharynx, this has not been generally accepted and hence remains a matter of much controversy. In the opinion of the writer the brain commissure which lies distinctly anterior to the pharynx (Fig. 8) can be used as a land mark only and in a different state of contraction might have its relative position changed. The innervation is no doubt distributed to the other anterior structures as well. Although the nerve commissure has the same relative position in the distomes this alone does not prove the phylogenetic origin of the pharynx, and when a muscular sucking apparatus is found and proof established of such an organ anterior to and adjoining the pharynx, as predicted by Cohn (1904), then and only then can these organs be safely designated as oral sucker and pharynx.

In this study the writer has examined more than one hundred specimens of the genus Cyclocoelum Brandes comprising at least fifteen different species. In this material different conditions are found. In *Cyclocoelum obliquum* Harrah 1921, *Cyclocoelum halli* nov. spec. *Cyclocoelum obscurum* (Leidy), *Cyclocoelum triangularum* nov. spec. a very weak and scarcely distinct oral sucker is present. The concentration of tissue is scarcely discernible except under the best optical conditions and even in sections there appears only a concentration of tissue at this point (Figs. 36–42). The outer circular band or sheath is found to be very light and not a continuous band as in *Cyclocoelum elongatum*. The above condition has been found to obtain in *Cyclocoelum problematicum* Stoss. and *Cyclocoelum tringae* (Brandes). In these species the sucker musculature is easily overlooked and when not taken into account the mouth opening agrees well with the structure so clearly described by von Siebold (1835) and van Beneden (1858) and that named prepharynx by Monticelli (1892). On the

other hand in *Cyclocoelum pseudomicrostomum* an intermediate condition is found. On first observation the mouth opening appears like the one just described; however, on more careful scrutiny a light but well formed sucker is discernible. In this case, however, the longitudinal and oblique muscles are actually increased immediately surrounding the buccal duct which leads inward toward the very muscular pharynx (Fig. 43). From this more or less muscular wall, radial muscles extend outward having their origin in a weak band of circular muscles. This outside covering of the sucker is held in place by the same sort of transverse muscles as in the distomes. Were this the only case found one could perhaps accept Cohn (1902:715) who has observed what he terms a rudimentary mouth sucker in *Cyclocoelum mutabile* (Zeder).

The maximum condition observed by the writer was that found in *Cyclocoelum elongatum*, in which posterior to the opening of the mouth, which is downward as before, is seen a large weak oral sucker scarcely visible in toto preparations. It is from one-third to one-half larger than the pharynx posterior to it and extends from the extreme anterior of the animal to well over the anterior portion of the pharynx. It measures 314μ in length by 463μ in width. The musculature is much less strongly developed than that of the pharynx and consists of an outer circular layer connected by radial, longitudinal, and oblique muscles to a much heavier inner circular band which forms the muscular walls of the mouth (Figs. 44, 45, 47, 48). This muscular body is suspended by much lighter strands of transverse muscle having their origin in the musculature of the body wall and their insertion at times in the outer circular band of muscles covering the sucking musculature and again in the radial muscles of the sucker itself. In general the position of this sucker is such that it opens downward but suspended as it is a slight contraction of the dorsal suspensory muscles and at the same time a relaxation of the ventral ones could easily give to the sucker a different position so that its aspect would be changed from that of its true antero-ventral one (Fig. 29).

In all specimens studied the writer has found evidence of the oral sucking mechanism and believes it to be a universal character in this family. In a study of *Haematotrephus similis* Stossich a sucker almost as heavy as that of *Cyclocoelum elongatum* was found (Fig. 28), and in the former species the sucker is considerably more prominent than in *Cyclocoelum pseudomicrostomum* and *Cyclocoelum mutabile*. *Cyclocoelum microstomum* could not be obtained for study of this feature.

Following the oral sucker is a thin walled, lightly muscular tube extending posteriad and ventrad to the pharynx and opening into it on the ventral side. The writer believes this to be a condition due to the state of contraction at the time of preservation and that in a fully extended specimen the oral opening would enter the pharynx from the anterior face,

thus leaving some 150 to 200μ between the oral sucker and the pharynx. This portion is termed the prepharynx (Fig. 29).

As will be seen by the description which is to follow later the structure of the pharynx is practically identical in many of the species of this and other families and therefore must necessarily have developed from a similar tissue in a similar manner. This being the case there remains the functional differentiation which may come about in the absence of a well developed oral sucking structure. No doubt the pharynx aids the weak sucker in drawing in food and it is highly probable that the suction produced by these heavy muscular walls is indeed very great. As was stated earlier in this discussion the position of the oral sucking apparatus relative to the pharynx in all those species which do not possess a strong oral sucking apparatus strongly indicates this view.

As was stated before the muscular bulb, or pharynx of Monticelli, is identical in structure and has no doubt arisen in the same manner in all the species of this family. Even though it may function as a sucking organ in some instances this structure has not been modified and does not appear to be typical sucker tissue as it has been described in other trematodes. If, however, this muscular organ is present in one or more species of this genus at the same time with a distinct anterior musculature which is typical of that tissue as found in other groups of trematodes and is constant in these species, then one is justified in designating the anterior musculature a sucking organ or oral sucker and the musculature posterior to it a pharynx as it was termed by Monticelli (1892).

Immediately posterior and dorsal to the prepharynx is a muscular structure developed around the wall of the posterior prepharynx or anterior esophagus. On first observation the pharynx appears as two bean-shaped halves lying one on either side of the anterior portion of the esophagus. On more careful study, however, it is found to consist of heavy muscular halves bound together on the edges by smaller bands of fibers so that in the true cross section it appears as a cylinder with an elongated dorso-ventral slit passing through it.

The pharynx is variable in size and form within the species as well as in different species, and may be in some species distinctly elongated while in others it is noticeably expanded laterally and still in others it is spherical. It measures in *Cyclocoelum pseudomicrostomum* 778μ and is slightly longer than broad. In *Cyclocoelum obscurum* it is in general spherical and measures 215 to 298μ. In *Cyclocoelum macrorchis* it is distinctly longer than broad and measures 264 to 314μ in length by 198 to 248μ in width. In *Cyclocoelum elongatum* the pharynx is oblong measuring 264 to 331μ in length by 215 to 281μ in width. While the range of measurements gives a general idea of the size and shape of the pharynx this study has shown

that the individual which has the longest pharynx is not always the one which has the narrowest one and vice versa.

As stated above the size and form of the pharynx is not constant as might be indicated by an average or range of measurements. *Cyclocoelum obscurum* shows eight instances in which the pharynx is round, two with a greater width than length, one with a greater length than width; this gives an average for eleven specimens of 230μ in length and 231μ in width, agreeing closely with the record that eight of the eleven cases cited show the pharynx to be spherical. From the range one would infer from the maximums that the pharynx is spherical but from the minimums of less transverse diameter than longitudinal. In *Cyclocoelum macrorchis* and *Cyclocoelum elongatum* every specimen measured shows for the pharynx a greater length than width while in *Cyclocoelum pseudomicrostomum* and *Cyclocoelum obscurum* some were spherical while the majority have a greater length than width. From this comparison one can see readily that the pharynx possesses such variability in size and form in this genus that it can be termed at best only spheroidal.

The musculature of the pharynx is, as stated previously, similar in all the species of this genus and consists of numerous fibers bound into bundles that are so interlaced as to make a very powerful organ and in the absence of the strong oral sucker it is quite probable that it serves as a sucking organ as was stated earlier in this work.

The musculature is quite characteristic of this organ as it has been described in other trematodes and consists of circular, radial and longitudinal fibers. The circular muscles are most numerous and constitute approximately 75 percent of the entire structure. They are pierced by bundles of radial muscles which have their origin in the outer layer of circular muscles and their insertion in the inner layer of the same muscles whose fibers intertwine all the muscles of the circular and radial type, particularly at their origin and insertion.

In most cases this muscular bulb stands with the anterior end open thus forming a continuation of the funnel shaped mouth opening to the posterior end of the pharynx which in all instances observed by the writer is closed just anterior to the esophagus that leads caudad from this organ.

The esophagus is a thin walled tube of varied length. In *Cyclocoelum elongatum* it measures 347 to 463μ; in *Cyclocoelum obscurum* 331 to 662μ; in *Cyclocoelum halli* 483μ on the average. The wide range of variation in length is due to the fact that the esophagus takes an S-shape (Fig. 29) which is no doubt due to a state of partial contraction taken at fixation. This condition makes it impossible to secure the exact length of this organ. Because of the different states of contraction the esophagus is more sinuous in some specimens than in others and consequently shows a much greater variation in length. In view of this fact the writer can place very little

weight on the exact length of the esophagus as a specific characteristic. In fact in some cases where the toto specimen showed the esophagus to be very short, sections of the same specimen gave evidence of a relatively long but much folded tube due no doubt to contraction.

In the case of *Cyclocoelum obscurum* stated above the length varies from 298 to 662μ making an average for the eleven specimens of 419μ. Under the conditions mentioned the average does not represent the actual length of the esophagus. It was noted from a study of this collection that the esophagus of one individual was more than twice as long as that of another. However, the maximum length of the esophagus is not represented by the maximum measurements secured since in no case has the writer observed the esophagus when it could be said to form a straight line from the oral sucker to the pharynx. The normal condition is represented in figure 29 where the esophagus arises at the dorsal portion of the pharynx and from there takes a winding course both laterally and dorsoventrally to the intestinal bifurcation into which it empties directly from the ventral side of the latter organ. The esophagus bifurcates at the posterior portion of the first body sixth to form the intestinal crura. One branch passing to the right, the other to the left side of the body, thus forming an arch which lies in the anterior one-sixth of the body. The crura extend from this parallel to the body wall, being separated from it only by the vitellaria, to the extreme posterior end where they anastomose forming a posterior arch. This is separated from the posterior body wall by the excretory bladder. The crura are usually large with a large lumen. However, in some cases they are extremely irregular and show in a few instances more or less distinct pouches which in some individuals appear as distinct diverticula and in fact are as strongly exemplified as some of those shown by Stossich (1902) and Kossack (1911) for the genus Typhlocoelum. This feature, however, is not constant for any species of the genus Cyclocoelum observed by the writer and is probably due to the pressure produced by expanded uterine loops which fill out the space between the crura and in many instances reach over the crura. Anterior to the intestinal bifurcation in *Cyclocoelum macrorchis* and *Cyclocoelum obscurum* there is an evagination which makes a pronounced undivided neck to the crura into which the esophagus opens. This appears in every specimen of the fifty-six in the two collections. This condition is in decided contrast to the other species studied. In these specimens, however, the intestinal crura are comparatively empty and show a generally relaxed condition whereas in most of the other specimens the crura are well filled and apparently well extended. It is probable in view of the relaxed and empty condition of the crura of the former species that the neck of the bifurcation is the result of the condition rather than a constant character for the species.

The excretory system of these worms cannot be fully made out in preserved material and at most one can obtain accurate knowledge of only a small part of this system without having had opportunity to study developmental forms while living. In general the excretory bladder can be made out in all species as a simple flattened sac, except in *Cyclocoelum elongatum*, lying between the posterior arch of the intestine and the body wall, usually closely approached on either side by the posterior extremities of the vitellaria. It opens to the exterior on the median dorsal surface by a small duct surrounded at its exterior opening by a strong sphincter. Two main branches of the system open into the excretory bladder one on either side. These branches follow in general the course of the intestinal crura and are joined by many secondary branches which anastomose freely forming a vast net-work ramifying the entire body. The ducts of the system are composed of relatively heavy muscular walls which aid in the movement of the excretory products toward the bladder.

The nervous system so far as has been made out from the material at hand does not differ materially from the description of Lang (1880). The cephalic ganglia are situated one on either side of the pharynx and are connected by a dorsal commissure which spans the anterior alimentary organs between the pharynx and the sucker. In the miracidia are seen the beehive-shaped eye-spots first observed by Van Beneden (1861) and later described by Faust (1918).

The vitelline glands in this family are very much alike in all genera being composed of two main canals which lie parallel to and usually outside of the intestinal crura. From these main stems side branches go out both dorsally and ventrally. The glands are made up of small follicular bodies arranged around the ducts so as to form grape-like clusters. The development of these glands is constant within a species and may be built up on the main stem with relatively few branches. The strongest development of the secondary branches is found in *Cyclocoelum microstomum* and *Cyclocoelum pseudomicrostomum* and in the genus Hyptiasmus where the branches of the vitelline glands form a net-work closely applied to the intestinal crura. The vitelline substance is conveyed to the ootype by a duct from each side in the region of the ovarian complex; these pass to a point posterior to the shell gland where they unite. At the point of union is usually found an enlargement, the vitelline reservoir. The duct then passes to the dorsal side of the shell gland where it becomes embedded in the latter organ; however, it emerges from this to re-enter it on the anterior dorsal surface and just after its entry joins the oviduct at the point of its enlargement to form the ootype.

The cirrus pouch as stated by Kossack (1911) shows little variation. It is a clubshaped muscular pouch containing a relatively large vesicula seminalis to which unites a short weakly developed pars prostatica. This

gives rise to a relatively large cylindrical unarmed ductus ejaculatorius. In most individuals the ductus ejaculatorius and pars prostatica are much coiled inside the cirrus sac and can be made out only with considerable difficulty. The writer has had the good fortune to have for study two specimens of *Cyclocoelum brazilianum* Stoss. one of which has the ductus ejaculatorius protruded from the body. The other one with the ductus ejaculatorius extended into the uterus in a case of evident self-copulation. (Figs. 31, 35). In these specimens the ductus is in excellent position for study and appears as described above. Through the union of the end portion of the cirrus pouch and the uterus a relatively large genital atrium is formed.

The form of the genital glands throughout the family is in general very similar. They are usually round or elliptical, sometimes flattened from pressure of the surrounding parts, with the exception of *Cyclocoelum vicarium* (Arned.) and in the genus Typhlocoelum in which species the testes are lobed. The genital glands of the genus Cyclocoelum, the only American genus thus far known belonging to this family, are spherical in form. The testes are located so the posterior is in or near the posterior intestinal arch and the anterior, a greater or less distance from this, separated often by uterus loops. Exceptions to this are found, however, in *Cyclocoelum oculobium* (Cohn) and *Bothriogaster variolaris* Fuhrmann in which the ovary occupies the posterior intestinal arch while the testes are situated in the middle region of the body. The vasa efferentia given off from the testes unite a short distance anterior and median to the anterior testis in *Cyclocoelum obscurum*, to form the vas deferens which makes its way between the uterine loops to the cirrus pouch previously described. The ovary is spherical and communicates by a short duct to the compact closely lying shell gland.

The presence of the receptaculum seminis and Laurer's canal have been held in question since the earliest accurate work on the anatomy of these worms, that of von Siebold (1835) who described in *Monostomum mutabile* as organs contributing to the formation of the egg four distinct glands, the vitellaria, which he interpreted as the ovary as follows:—"Die Ovarien bilden kurze blinde Schläuche, die unter einander anastomosiren und den Darmkanal, nachdem er vom Oesophagus aus die Seitenränder des Leibes erreicht hat, in seinem ganzen weiteren Verlaufe wie ein Netz umgeben. Es ist dies eine eigenthümliche Anordnung, die ich bis jetzt noch bei keinem anderen, zu den Trematoden gehörigen Wurme angetroffen habe." The three other parts having to do with the formation of the shell are described by the following characteristic statements:—"An der zweiten Abtheilung der weiblichen Geschlechtstheile, die zur Bildung der Eierhäute bestimmt zu sein scheint, lassen sich deutlich drei eigenthümliche Organe erkennen. a) Erstens fällt hier ein runder, weissgelber Körper

in's Auge, der zur rechten Seite dicht neben und vor dem hinteren Hoden liegt, und an Umfang etwas kleiner als dieser ist. b) Diesem runden Körper hängt zweitens nach innen ein ovaler, noch kleinerer und ebenfalls weissgelb gefärbter Körper an, der mit ersterem durch einen kurzen, anfangs weiteren, nachher engeren Kanal in Verbindung steht. c) Endlich liegt drittens, theils unter diesen Organen, theils zwischen dem runden Körper und dem hinteren Hoden eine durchsichtige, fast farbelose und unregelmässig umgränzte, feinzellige Masse, in die der gemeinschaftliche kurze Ovariengang einmündet, und aus der der eierführende Uterus hervortritt. Es ist mir bis jetzt nicht gelungen, eine Verbindung dieses unregelmässigen Organes mit dem grösseren runden Körper bestimmt nachzuweisen; doch bin ich überzeugt, dass eine solche wirklich existirt." Van Beneden (1861) in his study of *Monostomum mutabile* after characterizing the vitellaria (vitellogène Van Beneden, Ovarien von Siebold) and the ovary (germigène Van Beneden, one of the shell forming organs of von Siebold) says (p. 74), that besides the testes and the ovary only one other organ has been observed by him in the posterior region i.e., the vitelline duct which dilates to form the vitelline reservoir. In regard to the other organs described by von Siebold (1835) he says "Sont-ce la les deux autres organes que M. von Siebold signale et qui contribuent à la formation des oeufs? Cela est probable!"

More recently Braun (1892) stated that he is able to find the receptaculum seminis only in Aploblema, Cephalogonimus and in the distomes, and that on the basis of his own research Laurer's canal is wanting in *Monostomum mutabile*. One year later he states that in the monostomes a Laurer's canal appears to be wanting. Cohn (1902) reported the absence of both these organs in *Monostomum oculobium*. On the contrary Stossich in the same year after a thorough study of the group confirmed the presence of these organs in several species belonging to at least three genera of this family. Arnsdorff (1908) describes for *Monostomum vicarium* a small receptaculum seminis. Kossack (1911) after a study of a large number of specimens belonging to different genera of this family, viz: Cyclocoelum, Typhlocoelum, Haematotrephus, Hyptiasmus, states contrary to the finding of Stossich that both receptaculum seminis and Laurer's canal are wanting in this family. S. J. Johnston (1916) makes no mention of either the receptaculum seminis or Laurer's canal in any one of the three genera studied, Cyclocoelum, Haematotrephus and Hyptiasmus.

In a study of a considerable number of specimens belonging to several species of the genus Cyclocoelum the writer has observed the presence of the receptaculum seminis. In addition to the observations made on the American material the writer has been given the opportunity through the efforts of Professor Henry B. Ward and the courtesies extended him by the Curators of the museums of Berlin, Göttingen, and Vienna, to study *Cyclo-*

coelum mutabile, *Cyclocoelum problematicum*, *Cyclocoelum ovopunctatum*, *Cyclocoelum brazilianum*, *Cyclocoelum tringae*, and *Haematotrephus similis*. In all of these species a small spherical receptaculum seminis has been found, in position median and dorsal to the ovary (Figs. 20-24, 26 and 27).

On the same dorsal level with the receptaculum semnis and posterior to the latter and the ovary one finds the compact shell gland, in size approximately equal to the ovary. It is composed of unicellular glands closely packed together, each of which empties its secretion into the ootype by means of a short straight canal; these ducts form the inner portion of the gland. The ootype in the central portion of this gland gives rise to the uterus which in turn expands, immediately upon emerging, into a large receptaculum semnalis uterinum. During the sexual activity of the worm this pouch is filled with spermatozoa. In the genus Cyclocoelum, the uterus forms relatively short closely packed loops, in general going out from the middle line of the body. Relatively few stretches go directly across the body. The uterus fills out the entire space between the crura, then by a relatively straight stretch it spans the distance to the genital atrium in the region of the pharynx. In lateral extent the uterus reaches in general to the middle or outer wall of the intestine or rarely even out to the body wall, as in *Cyclocoelum halli*. This species differs in this respect from other species of the genus and according to the generic limits of Kossack does not belong here if this condition is a diagnostic factor. *Cyclocoelum halli*, however, conforms so closely to the genus in other respects and does not conform to the genus Haematotrephus in that the uterine loops do not bend around the genital organs so that the writer feels justified in placing it in the genus Cyclocoelum. Evidently there is little justification for the creation of a new genus based largely on the extent of the uterus and hence the limits of the genus Cyclocoelum have been extended to include this species.

The condition known as a situs inversus is a common feature of this family. Looss (1899) asserted that in all forms in which the genital pore is median there is a possibility that sexual amphitypy will occur and suggested that in Monostomes where this is the case situs inversus will probably be found. Cohn (1902) was the first to record this condition in the group when he found in *Spaniometra oculobia* (Cohn) a situs inversus of the genital glands in a ratio of 9:5. Kossack (1911) added to this by his observations on *Cyclocoelum problematicum* Stoss., *Cyclocoelum ovopunctatum* Stoss., and *Cyclocoelum vicarium* (Arnsd.) in which he says that on the average the right and left positions are equally frequently present.

The writer has found a similar condition to exist in all species of Cyclocoelum represented in North America as well as being able to verify the observations of Kossack on *Cyclocoelum problematicum* and *Cyclocoelum ovopunctatum*. Reference to the following table shows that the right and

left positions are on the whole equal in number and where significant differences occur they are perhaps due to the small number of individuals studied. In *Cyclocoelum obscurum* with sixty specimens in the lot the difference is relatively small. The total of ninety-four specimens in all show an approximately equal count for each arrangement.

	Anterior testis		Cirrus pouch		Number of uterine loops between testis										Total uterine loops on side of anterior testis				
	Rt.	Lt.	Rt.	Lt.	0	1	2	3	4	5	6	7	8	9	25–30	30–35	35–40	40–45	45–50
C. obscurum...	34	26	28	32	1	1	5	...	...	...	4	6	3	1	9	23	22	5	...
C. elongatum..	4	4	3	4	...	...	...	...	1	5	1	1	...	...	...	...	2	3	2
C. pseudomicrostomum...	3	1	2	2	...	...	...	...	1	...	1	1	...	1	1	2	1	...	...
C. macrorchis..	8	14	7	15	1	6	3	6	1	3	2	...	...	...	1	4	12	5	...
Total numbers.	49	45	40	54	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

The variation in the position of the testes from one another is equally of little importance from the standpoint of specific diagnosis. However, since Stossich used this as the means of separation of species in Cyclocoelum and Haematotrephus the writer feels it worth while to give here the result of observations on American material. Kossack raised objections to the importance assigned this point by Stossich and showed that the variation within a species was even greater than that between the genera before mentioned.

The study of the American material has served to substantiate the view of Kossack (1911) reached by study of the European material. Reference to table shows the number of uterine loops to vary from none where the testes lie contiguous to one another to nine while the entire number of uterus loops, counted always on the side of the anterior testis, is likewise variable and appears to bear no relation to the total number of uterine loops between the testes of the individual since the specimen which showed nine loops between the testes has in all only 38 loops while in another individual of the same lot of *Cyclocoelum obscurum*, which had a total of 40 loops only 3 could be found between the testes. Other examples are 8 and 43; 3 and 44; 7 and 39 as compared to 1 and 39. These are a few examples taken from *Cyclocoelum obscurum*. Other species show the same to be true except in *Cyclocoelum halli* and *Cyclocoelum triangularum* where the relative positions of the genital glands appear to be constant. How-

ever, since the number of specimens here is small the writer is inclined to attach relatively little importance to this feature.

The life history of this group is relatively unknown, although the earliest record of a monostome larva is said to date from 1817. An early account is found in Filippi 1859. This author obtained from *Bythinia tentaculata* (L) [= *Paludina impura* of Filippi] a larva he named *Cerceria lophocerca* which he described (1859:5) as follows: "Elle est caractérisée par un bulbe pharyngien assex fort, par la présence de deux yeux ou taches pigmentaires semilunaires avec une petite lentille dans la concavité, et par une queue munie d'une crête membraneuse longitudinale. Dans l'intérieur du corps on voit des rudiments d'organes sexuels sous la forme de trois masses vésiculaires."

According to Lühe (1909) the determination of Filippi is doubtful since the description and figures show a close resemblance to *Cercaria fulvopunctata* Ercol. which is an undoubted distome larva. Cort (1915) on the other hand recognized distinct features in this larva and stated that it is "entirely different from all other monostomes known." As such it stands alone and unidentified.

While the description of Filippi is meager and bereft of many diagnostic characters a few outstanding features point to its alliance to this group. This relationship is shown by the absence or at most only poorly developed oral sucker (Filippi, pl. I, fig. 3), by the presence of a strongly developed pharynx, and by the position of the three "rudimentary" sex organs.

Key to species of Cyclocoelum

1(6) Uterus restricted to the intercecal zone 2
2(5) Testes unequal in size 3
3(4) Pharynx larger than oral sucker; ratio of posterior testis to ovary 2:1 ..... *Cyclocoelum mutabile* (Zed.)
4(3) Oral sucker and pharynx small, approximately equal in size; ratio of anterior testis to ovary 4:3 ..... *Cyclocoelum cuneatum* nov. spec.
5(2) Testes equal in size. Oral sucker larger than pharynx; ratio of testes too vary 3:1 ..... *Cyclocoelum leidyi* nov. spec.
6(1) Uterus not restricted to intercecal zone 8
7(26) Uterus folding around the crura both dorsally and ventrally ... 9
8(21) Gental glands separated by uterine loops 10
9(16) Testes equal in size 11
10(13) Pharynx larger than sucker; vitellaria extending laterally beyond medial wall of crura 12
11(12) Ratio of testes to ovary 5:2 ..... *Cyclocoelum pseudomicrostomum* nov. spec.
12(11) Ratio of testes to ovary 4:3 ... *Cyclocoelum microstomum* (Crepl.)

13(10) Sucker larger than the pharynx.....15
14(15) Vitellaria strongly developed, extending to inner wall of intestine; ratio of testes to ovary 2:1..... ..... *Cyclocoelum macrorchis* nov. spec.
15(14) Vitellaria weakly developed, rarely reaching middle of crura; ratio of testes to ovary 2:1..... ..... *Cyclocoelum vicarium* (Arnsd.)
16(9) Testes unequal in size.....18
17(20) Oral sucker twice as large as pharynx.....19
18(19) Ratio of posterior testis to ovary 2:1..... ..... *Cyclocoelum obscurum* (Leidy)
19(18) Ratio of posterior testis to overy 3:1..... ..... *Cyclocoelum ovopunctatum* Stoss.
20(17) Oral sucker not twice the size of pharynx. Ratio of posterior testis to ovary 3:1..... *Cyclocoelum problematicum* Stoss.
21(8) Genital glands contiguous, not separated by uterine loops...24
22(25) Testes unequal in size; oral sucker twice as large as pharynx 25 ..... *Cyclocoelum wilsoni* nov. spec.
24(23) Ratio of posterior testis to ovary 2:1..... ..... *Cyclocoelum tringae* (Brandes)
25(22) Testes equal in size; oral sucker and pharynx approximately equal. Ratio of testes to ovary 10:7..... .....*Cyclocoelum triangularum* nov. spec.
26(7) Uterus passing dorsally over intestinal crura and vitellaria to body wall; vitellaria moderately developed, rarely extending beyond middle of crura.....30
27(28) Sucker 1½ times pharynx; testes unequal; ratio posterior testis to ovary 3:2..... *Cyclocoelum brazilianum* Stoss.
28(29) Sucker and pharynx equal in size; testes equal; ratio of testes to ovary 2:1.....*Cyclocoelum halli* nov. spec.

Description of species

CYCLOCOELUM LEIDYI nov. spec.

[Figures 1, 2, 33]

Syn: *Monostomum mutabile* Leidy 1885, nec Zeder 1800

This collection contains five specimens described by Leidy (1885) as follows: "From the thoracic cavity of a Gray Snipe, *Gallinago wilsoni*, Dr. Warren (of Westchester) obtained five Flukes, 18mm long, by 4mm broad. These appear to be *Monostomum mutabile.*"

These specimens are readily recognized as belonging to the genus Cyclocoelum Brandes (1892) but are distinctly different from *Cyclocoelum mutabile* and represent a new species. The following description shows the characteristic differences between the two species.

These flukes are 16 to 18 mm long by 4 to 4.5 mm broad. The margins of the body are practically parallel in the posterior two-thirds of the body. The anterior one-third tapers to a weakly rounded point. The subterminal mouth is surrounded by a weakly developed sucking musculature which is approximately three times the size of the small pharynx. The small ovoid pharynx measures 231μ broad by 281μ long. The slender esophagut which is curved in the form of an S measures 331μ in length. It opens inso the middle of the dorsal side of the intestinal bifurcation. The voluminous intestinal crura run parallel to the margins of the body throughout their entire course. The vitellaria are moderately developed and occupy the region lateral to the crura. They extend laterally to the inner wall of the crura and fold both dorsally and ventrally around them. They extend anteriorly not quite to the most anterior portion of the intestinal bifurcation and are separated at the posterior end only by the excretory bladder. The uterus fills the entire space between the intestinal crura. It lies in the mid dorso-ventral region, is profusely coiled and does not extend out beyond the inner wall of the intestine. Genital glands are confined to the posterior intestinal arch. The posterior testis is situated in the middle line of the body and lies directly in the arch formed by the intestine. The anterior testis is a little removed and is contiguous to the crura. They are equal in size and measure 877 to 910μ in diameter. The much smaller ovary lies on the side of the body opposite to the anterior testis and in a transverse plane between the two testes. It is spherical and measures from 380 to 390μ in diameter. Dorsally and on the inner posterior side of the ovary is a small spherical receptaculum seminis 82 to 99μ in diameter, which joins by a short duct the oviduct shortly after its emergence from the ovary. Laurer's canal is not present. As the oviduct passes posteriorly into the adjacent shell gland aggregate it is joined by the vitelline duct. At this point the oviduct enlarges to form the ootype. Just after the uterus emerges from the compact shell gland a second enlargement is seen, the receptaculum seminalis uterinum. It extends posteriorly to the crura where it doubles on itself and pursues its coiled winding course to the genital pore which is situated ventral to the middle region of the pharynx. The cirrus pouch is 182μ broad by 331μ long and reaches to the middle of the intestinal crura at their bifurcation. The genital pores open separately into a small genital atrium. Eggs thick shelled ovals, 66 by 117μ when fully mature. They contain in the anterior portion of the uterus well developed miracidia as evidenced by the dark eye spots.

Habitat: Thoracic cavity — Host: *Gallinago wilsoni*
Locality: Westchester, Pa. — Date: 1885
Collector: Dr. H. W. Warren — No. 106 Leidy Collection.

A comparison of this material with the data given by Stossich (1902: 13) and by Kossack (1911:510) for *Cyclocoelum mutabile* (Zeder) as well as

comparison with specimens of *Cyclocoelum mutabile* obtained from the Göttingen museum demonstrates clearly that this is a distinct species. It is similar to *Cyclocoelum mutabile* in the size and form of the body, in the lateral extent of the uterine loops, the extent and development of the vitellaria, the size of the ovary, and the size and shape of the eggs.

It differs from this species in having a much smaller pharynx, a much larger sucker, a longer esophagus, larger testes, and a relatively heavier and more irregularly folded uterus. This species is similar to *Cyclocoelum problematicum* Stossich in the size of the testes and the extent of the vitellaria but differs from that species in having a smaller pharynx and a broader, thinner and less muscular body in proportion to its length. For comparison with this species a figure (Fig. 3) of *Cyclocoelum mutabile* (Zed.) is placed beside that of *Cyclocoelum leidyi*.

CYCLOCOELUM PSEUDOMICROSTOMUM nov. spec.

[Figures 4, 27, 30, 43]

Large monostomes 13 to 14.5 mm in length by 4 to 4.5 mm in greatest width which is found at the beginning of the posterior body third. From this point forward the side walls taper gradually to the end of the anterior body third, at which point they bend inwardly more sharply to form a small obtusely rounded end. The posterior end is bluntly rounded. The mouth is subterminal, surrounded by an external banding musculature which measures 662 to 745μ in diameter. This is followed by a large heavy slightly elongate pharynx 778 to 910μ in length by 745 to 844μ in width. The genital pore lies median and ventral to the forward end of the pharynx. From this point the cirrus pouch stretches posteriad almost to the posterior wall of the intestinal bifurcation. The vitellaria extend from the posterior end of the cirrus pouch to the excretory bladder in the posterior end of the body. It is even more strongly developed than that of *Cyclocoelum microstomum* and in its lateral extent passes the inner wall of the crura and over the lateral folds of the uterine loops which in this species rarely pass over the inner wall of the crura. The testes as in other species of this genus lie in the posterior region of the body and within the intestinal crura. The posterior testis does not fill the entire intestinal arch, is antero-posteriorly flattened and measures 827 to 910μ in width by 993 to 1192μ in length, while the anterior testis which is separated from it by uterine loops measures 745 to 993μ in width by 1076 to 1324μ in length. The ovary lies on a level with the anterior margin of the posterior testis and adjacent to the cecum opposite to the anterior testis, is much smaller and spherical, measuring 413 to 496μ in diameter. Dorsal to the ovary is the spherical receptaculum seminis 148 to 165μ in diameter. The shell gland is similar in size to the ovary and occupies a position dorsal and posterior to that structure. As was stated above the uterus does not usually pass over the

inner wall of the intestine and fills out entirely the space between the crura. The eggs are thick shelled ovals, 51 to 66μ in width by 102μ in length.

Habitat: Lung	Host: "Wild duck"
Locality: Omaha, Nebr.	Date: 1903
Collector: C. E. Stringer	No. 1041 Ward Collection

This species is also found in the Leidy Collection vial no. 186 which has been dried out and is in a poor state of preservation. John C. Johnson collected this species from *Fulica americana* taken at Golden Gate Park, San Francisco, Cal. in January 1919.

Cyclocoelum pseudomicrostomum finds its nearest relative in *Cyclocoelum microstomum* (Crepl.). The two species are of nearly equal size. The pharynx of the former is distinctly larger, the testes are not of equal size as in *C. microstomum* and are slightly broader than long probably due to pressure from the closely packed uterus. The ovary of *Cyclocoelum pseudomicrostomum* is noticeably smaller than that of *Cyclocoelum microstomum*, while the lateral extent of the uterus in the former species is more restricted. With respect to the development of the vitelline glands *Cyclocoelum pseudomicrostomum* presents the heaviest development found in any known species of this genus.

CYCLOCOELUM HALLI nov. spec.

[Figures 5, 11, 20, 36–42]

Large monostomes varying in length from 11 to 14 mm in width by 3 to 4 mm in greatest width which is found slightly posterior to the middle of the body. From this point the body tapers anteriorly to almost a point and posteriorly only a little, forming an obtusely rounded end. The body is muscular, dorsally convex, and ventrally flat or slightly concave. The body wall is entirely covered with numerous small pits observed by Zeder (1803) in *Monostoma mutabile.* The subterminal mouth leads by a funnel-shaped tube to the pharynx. This tube or mouth proper is surrounded by a concentration of musculature which on the outer margin is formed into circular bands, the outer covering of the sucker (Figs. 36 to 42). The sucker is spherical in form and measures 387μ in diameter. It is separated from the smaller (263μ) but more heavily muscular, spherical pharynx, by the nerve commissure. The esophagus is 483μ in length and extends from the posterior portion of the pharynx to the dorsal side of the intestinal bifurcation. The latter a simple tubular structure lies along the margins of the body for its entire length and anastomoses at the posterior end. As previously described the excretory system is composed of a system of tubules ramifying the entire body in this species, as in *Cyclocoelum elongatum.* These tubules anastomose and empty into the excretory bladder. In this species a single thin walled sac

which opens to the exterior by a small dorsal pore. The genital glands are situated in the posterior fifth of the body where they are closely packed in the posterior arch of the intestine, the posterior testis almost entirely filling this space. It is slightly flattened antero-posteriorly and measures in its greatest dimension 1052μ and in an axis at right angles to this, 894μ. The anterior testis situated a short distance cephalad to the posterior, is spherical in shape and a little smaller, having a diameter of 894μ. The two testes are separated by a particularly long loop of the uterus which extends to the intestinal arch, and in some instances even beyond, and usually folds back part way forming a double loop. The vasa efferentia given off from the anterior margins of the two testes unite cephalad and mesad to the anterior testis to form the vas deferens which takes a fairly straight course to the cirrus pouch with which it unites.

The cirrus pouch is a rather large oblong sac extending from the pharynx to a short distance beyond the anterior wall of the intestinal bifurcation. It opens into a small genital atrium which in turn opens to the exterior, ventral to the pharynx.

The ovarian complex is situated opposite to and on a level with the anterior testis. The ovary is very much smaller than the testes, measuring 434μ in diameter. Dorsal to this is the receptaculum seminis, the duct from which joins the oviduct before it enters the shell gland. The shell gland, a compact spherical organ, is situated dorsal and posterior to the ovary. It has a diameter of 388μ. The vitellaria lie between the lateral body wall and the external wall of the digestive crura over which they seldom pass. They extend from the posterior pharyngeal region to the extreme posterior end where they are separated by the excretory bladder. The vitelline glands are made up of small follicular grape-like clusters arranged along a main stem, which in the region of the anterior testis gives rise to the vitelline ducts. These pass mesad and unite a short distance posterior to the shell gland to form the common duct which passes straight to the shell gland. It enters this at the posterior side and passes through the outer portion of this organ to its union with the oviduct just after the entrance of the latter into the shell gland. The oviduct then enlarges to form the ootype. On emergence from the shell gland the uterus enlarges to form a large pouch, the receptaculum seminalis uterinum. From this the uterus makes a few short loops and then the long loop, previously mentioned, which separates the testes. From this point forward it lies in more or less regular transverse folds which extend out to the vitellaria, tho in some instances, particularly in the posterior three-fifths of the body, these loops extend to the body wall. In the anterior fifth of the body the uterine loops are not so long and here fill out entirely the space between the intestinal crura. From the

bifurcation of the intestine the uterus reaches in a relatively straight stretch to the genital atrium.

The eggs are large, thick shelled ovals, measuring 161 μ in length by 99 μ in breadth. The double, dark eyespots give evidence of the developing miracidium within the eggs before they have passed in their course anterior to the middle region of the body.

Habitat: Abdominal air-sacs. Locality: host taken in Raleigh (?) N. C.
Host: *Totanus melanoleucus* Collector: W. C. Hall
Date: April 7, 1894
No. 21.90 Ward collection

Habitat: Liver? or Lung? Locality: Creston, Iowa
Host: *Totanus solitarius* Collector: W. C. Hall
Date: Aug. 30, 1895 No. 21.763 Ward collection

Filed among the records of Hall is a statement that he collected 5 specimens from the air sacs of *Totatnus flavipes* Sept. 4, 1895, which he believed to be this species. The material from this host has not been found.

This species is most closely related to *Cyclocoelum brazilianum* Stossich and resembles that form in the lateral extent of the uterus, the relative position of the genital glands, and in the size of the ovary. It differs, however, in the size of the testes, the more weakly developed vitellaria, and relative size of the oral sucker and pharynx, these being of equal size in *C. halli* while in *C. brazilianum* the sucker is distinctly larger than the pharynx.

CYCLOCOELUM WILSONI nov. spec.

[Figure 6]

Medium sized monostomes 12 mm long by 3 mm wide in maximum which is found at the beginning of the posterior one-fifth of the body. Posterior and bluntly rounded. Anterior to the point of greatest width the body tapers gradually to a blunt but relatively small point. The mouth sucker measures 374 μ in diameter and is one-third larger than the oval pharynx which measures 298 μ in length by 269 μ in width. The esophagus is relatively long and gives rise by bifurcation to the simple intestinal crura, which as in other species run parallel to the body wall and anastomose in the posterior end of the body. The genital aperture is ventral to the middle of the pharynx. The cirrus pouch extends from this point to the middle of the intestinal bifurcation. The follicular yolk glands extend from the anterior wall of the intestinal bifurcation almost to the excretory bladder at the posterior end. In lateral expanse they pass over the external wall of the intestinal crura to the middle of that organ where they meet the furthest expanse of the uterus. The uterus in this species lies entirely anterior to the anterior testis and fills out the space between the crura, folding both dorsally and ventrally over the walls of

these to the middle region of the same. The genital glands lie contiguous to one another in the posterior arch of the intestine. The posterior testis lies a little posterior to and a little more nearly in the middle of the arch than the anterior one which is smaller and contiguous to the former, filling out the opposite portion of the intestinal arch. The testes are not separated by uterine loops as is generally true in this genus. The anterior testis is spherical, 910μ in diameter while the posterior testis is slightly elongated and measures 993μ in length by 910μ in width. The ovarian complex lies anterior to and adjacent to the posterior testis. The ovary and shell gland are spherical, equal in size, and measure 413 to 447μ in diameter. The small spherical receptaculum seminis lies partially embedded in the shell gland and measures 150μ in diameter. The eggs are thick shelled ovals and measure 150μ in length by 76μ in width.

Habitat: Intestine	Host: *Gallinago wilsoni*
Locality: Creston, Iowa	Date: August 4, 1894
Collector: W. C. Hall	No. 21.89 Ward Collection

The direct relationship of this species is not so readily apparent. As to position of the genital glands it holds a place close to *Cyclocoelum tringae* (Brandes) and *Cyclocoelum triangularum* nov. spec. and tho it is much larger presents in general the same characteristic features namely: genital glands contiguous, uterine loops directed backward, vitellaria moderately deveoped, oral sucker larger than pharynx. However, in the size of the body and the relative size of the pharynx and sucker as well as the relative size of the genital glands *Cyclocoelum wilsoni* is clearly distinct and must be recognized as a proper species.

CYCLOCOELUM CUNEATUM nov. spec.

[Figures 7, 24]

Medium sized worms 10.5 to 12 mm in length by 2.5 to 3.5 mm in greatest width which is found at the beginning of the posterior body fourth. From the point of maximum width the margins of the body run approximately parallel to the level of the anterior testis at which point they narrow abruptly to form the obtusely rounded posterior end. From the point of greatest width the margins of the body converge cephalad in almost straight lines to a very narrow and pointed anterior end, which gives the impression of a well formed wedge. At the pointed anterior end is found a very small weakly developed sucker, 198 to 215μ in diameter. This is followed by an oblong pharynx of approximately the same width as the sucker. It measures 150 to 198μ in width by 215 to 231μ in length. The esophagus is three and one-half to four times the length of the pharynx. The intestinal crura are simple. The vitelline glands extend from the middle region of the bifurcation of the intestine to the excretory bladder

in the posterior end. In lateral extent they rarely traverse the outer wall of the crura. The genital opening is located anterior to the pharynx. The cirrus pouch extends to the anterior wall of the intestinal bifurcation. The uterus fills out the entire space between the crura and its loops occasionally span the outer wall of the same organ. The genital glands are relatively small and occupy the positions so common to the species of this genus. The posterior testis, not filling out the intestinal arch, is anteroposteriorly flattened and measures 413μ in width by 496 to 612μ in length. The anterior testis is separated from the posterior by several uterine loops and is smaller and spherical, measuring 331 to 413μ in diameter. The spherical ovary is situated in a transverse plane anterior to and about equally distant from the two testes. It is one-fourth smaller than the testes measuring 215 to 331μ in diameter. The shell gland lies median and posterior to the ovary, is spherical or only slightly ovoid and equal in size to the latter organ. The receptaculum seminis although indistinguishable in toto mounts is clearly seen in sections. It is anterior and dorsal to the ovary. Wax reconstructions show it to be spherical and approximately one-half the size of the ovary, measuring 150μ in diameter. The ovarian complex is separated from the testes by uterine loops. The eggs are thick shelled ovals, 66μ wide by 115μ to 122μ long.

Habitat: Abdominal cavity	Host: *Gallinago delicata* (Ord.)
Locality: ?	Date: ?
Collector: ?	No. 08. 172 Ward collection.

The relationships of this species is not so evident as it partakes of the characteristics of a number of species. With respect to the lateral extent of the uterine loops it is more nearly like *Cyclocoelum mutabile* and *Cyclocoelum leidyi* while in development of the vitellaria it simulates *Cyclocoelum halli*. The pharynx and oral sucker are noticeably smaller than in any known species of this genus and this is a feature of this species as is also the small size of the genital glands and the proportionate size of the testes to the ovary, a ratio of 4:3.

CYCLOCOELUM OBSCURUM (Leidy)

[Figures 8, 21]

Syn: *Monostomum obscurum* Leidy 1887

This species was described by Leidy as follows: "Elongated, elliptical, flattened, obtusely angular in front, obtusely rounded behind, oral and genital and other aperatures scarcely distinguishable. Length 4 to 8 lines; width 1 line."

"Numerous specimens in the stomach of a Jew-fish, *Megalops thrissoides*."

The host name *Megalops thrissoides* used for the Jew-fish by Leidy 1887 is evidently a *lapsus calami*. However this is corrected by Stiles and Hassall (1894) to Stereolepis sp?

Brandes (1892) enumerates this among other species which he has not had opportunity to study and he justly says that it is inadequately described. Monticelli (1892) and Braun (1893) in spite of the meager description retain it as a valid species.

The original material of this species is found in the Army Medical Museum under Number 1035 Comparative Anatomy Series with the description "Flukes *Monostomum obscurum* from the stomach of a Jew-fish (Stereolepis)." From this I have written the following description.

Monostomes of medium size measuring from 6 to 13 mm in length and from 1.5 to 3 mm in maximum width which is found a little posterior to the middle of the body. The margins of the body are almost parallel for the greater part of their length, tapering gently to the more pointed anterior end and abruptly to form the obtusely rounded posterior end. As in most species of this genus the body is convex dorsally and flat or slightly concave ventrally. The subterminal mouth is surrounded by a weakly developed sucking musculature which measures 115μ in diameter. This leads to the spherical or slightly elongated pharynx, measuring 115 to 264μ in width by 115 to 298μ in length. Following this the slender esophagus, 500 to 750μ in length, leads to the intestinal bifurcation. The crura are quite variable in size as well as in the character of the median wall. In some cases they show a tendency to the formation of internal ceca; these appear to be due to the pressure from the closely packed uterus which fills the space between the crura. The excretory system in this species has not been made out except for the single termnal excretory vesicle situated as in the other species of this genus between the posterior arch of the intestinal crura and the posterior body wall. It opens to the exterior by a single dorsal pore. The genital organs lie within the intestinal crura in the posterior end of the body. The posterior testis, filling the posterior arch of the intestine, is flattened anteriorly by the closely packed uterine loops and is slightly larger than the anterior being 300 to 877μ in width by 480 to 1000μ in length. The anterior testis is usually more nearly spherical and measures 380 to 827μ in width by 462 to 827μ in length. It lies obliquely anterior to the posterior and adjacent to the crura. The vasa efferentia are short and unite a short distance anterior to the anterior testis to form the vas deferens which for the most part passes dorsal to the uterus to the cirrus pouch. This organ is of medium size 248 to 579μ in length by 115 to 199μ in width. In general its posterior limit lies on a level with the middle of the intestimal bifurcation. The ovarian complex lies between the testes and on the side opposite to the anterior testis. It is composed of a spherical ovary, 275 to 463μ in diameter, a spherical receptaculum seminis, 132 to 148μ in diameter, and a shell gland in size and form similar to the ovary. The position of these is clearly shown in figure 21. Beginning in the shell gland the uterus immediately upon

emergence enlarges to form the large receptaculum seminalis uterinum. It fills the intercecal space with more or less regular loops which in general go out from the middle of the body. These loops fold around the inner surface of the crura and usually do not pass beyond the outer wall of the latter organ. The vitellaria for the most lie outside the crura and extend from the pharynx to the excretory bladder. Laterally they reach to the middle of the crura and in exceptional instances to the inner wall of that organ.

Habitat: Stomach	Host: Stereolepis sp?
Locality: ?	Date: ?
Collector: ?	Cat. No. 1035 Comparative Anatomy series.
Habitat: ?	Host: *Symphaemia semipalmata*
Locality: Lincoln, Nebraska	Date: ?
Collector: ?	Cat. No. 08.179 Ward collection
Habitat: ?	Host: Unknown
Locality: Spokane, Wash.	Date: ?
Collector: W. E. Allen	Cat. No. 08.183 Ward collection

Cyclocoelum obscurum is most closely related to *Cyclocoelum ovopunctatum* Stossich and differs from that species in the more slender form, the more heavily developed vitellaria and the relative size of the testes to the ovary which in *Cyclocoelum obscurum* are twice as large as the ovary while in *Cyclocoelum ovopunctatum* they are three times as large.

CYCLOCOELUM MACRORCHIS nov. spec.

[Figure 9]

This species varies in length from 7 to 15 mm and in maximum width, which is found just posterior to the middle of the body, from 2 to 4 mm. From this point the body tapers towards both ends, the posterior being obtusely rounded while the anterior is considerably more attenuated. It forms a moderately rounded point. The margins of the body lie nearly parallel in the middle region of the body. The subterminal mouth is surrounded by a weakly developed musculature, the oral sucker, which is only a little larger than the well developed pharynx just posterior to it, and measures 255μ in diameter. The pharynx is oval in shape being about one-fifth longer than wide and measures on the average 271μ long and 238μ wide. The esophagus in this species is on the whole well extended and ranges from 331μ in the state of least extension to 662μ in that of greatest extension exhibited in preserved material. At its posterior end the esophagus turns ventrad and bifurcates forming the voluminous crura present in this species (Fig. 9). These as in other species of this genus lie parallel to the margins of the body and anastomose at the poster-

ior end. The excretory system as far as can be made out in preserved material conforms in this species to the description given previously in having a single thin walled vesicle in the extreme posterior end of the body into which the anastomosing tubules empty. It opens to the exterior slightly dorsal to the posterior end. The genital glands in general occupy the intercecal zone and fill entirely that space. The posterior testis occupies the intestinal arch, is usually spherical in form and measures 783 to 984μ in diameter. The anterior testis is usually removed from the posterior by several uterus loops. It is spherical and approximately the same size as the posterior measuring 730 to 860μ in diameter. As in other species of this genus the vasa efferentia unite cephalad and mesad to the anterior testis. From this point the vas deferens takes its course among the uterine folds to the posterior end of the cirrus pouch which is situated at the middle of the intestinal bifurcation. The cirrus pouch extends from the genital atrium caudad to the middle of the intestinal bifurcation. From this point the club-shaped cirrus pouch extends cephalad to the genital atrium and lies ventral to the anterior end of the pharynx. The ovarian complex is situated between the testes and adjacent to the crura opposite the anterior testis. The ovary is spherical and measures 413 to 463μ in diameter. Dorsal and posterior to the ovary is the spherical receptaculum seminis, 165μ in diameter. The duct of this unites with the oviduct before it enters the shell gland. The shell gland is approximately the same size as the ovary and is situated posterior and dorsal to that organ (Fig. 9). The well developed follicular yolk glands occupy the region of the body lateral to the intestinal crura and extend from the anterior-most part of the intestinal bifurcation to the posterior end where they are separated only by the small excretory bladder. The follicles are arranged in clusters on secondary branches from the main stem and in this manner extend laterad around the crura both dorsally and ventrally, in many cases reaching out as far as the inner wall of the crura. The vitelline ducts are given off in the region of the shell gland and pass mesad to a point just dorsal to the shell gland where they unite to form the vitelline reservoir. From this the common vitelline duct passes dorsal to the shell gland and joins the oviduct just before its entrance into that organ. Immediately upon entering the shell gland the oviduct enlarges to form the ootype. Upon emergence from this the uterus enlarges to form the receptaculum seminalis uterinum. From this point the much folded uterus fills out the entire space between the crura and passes over the bifurcation in a relatively straight stretch to the genital atrium. The numerous eggs which fill the uterus are thick shelled ovals, measuring from 122 to 153μ in length by 56 to 66μ in width. In general the eggs are smaller in the beginning of the uterus than they are near the genital orifice. The eggs in the anterior region show well developed miracidia with double dark eye spots.

Habitat: In lung and along the back in the abdomen. Host: Straight-billed Curlew

Collector: W. E. Allen No. 08.180 Ward collection

Cyclocoelum macrorchis differs from *Cyclocoelum mutabile* in that the uterus in the former is not restricted to the intercecal space and that the oral sucker is larger than the pharynx, where as in *Cyclocoelum mutabile* the vitellaria are more heavily developed and the genital glands are smaller. *Cyclocoelum macrorchis*, however, has a much more muscular and much thicker and heavier body.

CYCLOCOELUM TRIANGULARUM nov. spec.

[Figure 10]

Medium sized worms 8 mm long by 2.5 mm wide in maximum. Body lanceolate in form. Oral sucker weak, 260μ in diameter, only a little larger than the pharynx which is longer than broad, measuring 248μ in length by 215μ in breadth. The length of the esophagus is approximately one-tenth of the entire body length. Intestinal crura simple. Genital pore ventral to the posterior end of the pharynx. Cirrus pouch extending to the middle of the intestinal bifurcation. The vitellaria extends from the posterior end of the cirrus pouch almost to the excretory bladder at the posterior end of the worm. In lateral extent they pass over the wall of the crura to the middle of that organ. The genital glands lie in the posterior arch of the intestine and are not separated by uterine loops. The two testes lie on the same level, one in either side of the arch, are spherical and equal in size. They measure 413μ in diameter. The ovary lies anterior to the testes and in the middle line of the body. It is a little more than one-half the size of the testes, is spherical in form and measures 248μ in diameter. The shell gland lies between the ovary and testes also in the middle line of the body and measures 264μ in width by 314μ in length. The receptaculum seminis is situated anterior to the shell gland and dorsal to the ovary. Like the ovary the receptaculum seminis is spherical in form and measures 132μ in diameter. The eggs are thick shelled ovals 132μ long by 75μ wide.

Habitat: Abdominal air sacs Host: *Tringa maculata*

Locality: Creston, Iowa Date: September 4, 1895

Collector: W. C. Hall No. 21.88 Ward collection

As was stated in another section of this paper *Cyclocoelum triangularum* shows a striking similarity to *Cyclocoelum wilsoni* and is distinguished from that species by the generally smaller body, the more nearly equal sucker and pharynx, the testes of equal size and the relative size of the testes and ovary which in *Cyclocoelum triangularum* have a ratio of 10:7. It is more nearly equal in size with *Cyclocoelum tringae* but is distinguished from

this species by the larger pharynx, smaller sucker, the testes being equal in size and also smaller in proportion to the size of the ovary.

CYCLOCOELUM VICARIUM (Arnsdorff 1908) Kossack 1911

Syn: *Monostomum vicarium* Arnsdorff

The writer has not had opportunity to study specimens of this species and hence must rely upon the descriptions of Arnsdorff (1908) and Kossack (1911). Since the description of Kossack made after having studied the original material is at variance with the original description only in minor detail the writer has based the following description on the work of Arnsdorff.

Monostomes varying between 10.5 and 14.4 mm in length and 3 to 3.1 mm in maximum breadth. The body is opaque, flattened; ventral surface flat, dorsal slightly swollen. The sidelines of the body diverge from the small pointed anterior end to the height of the testes. From here they form the bluntly rounded posterior end. The dorsal surface of the body is quite wrinkled. These folds appear in optical section to form pappillae. The mouth opening is terminal. The strongly muscular pharynx is an elongate oval with a long diameter of 460μ and a breadth of 270μ. The thickness of its wall is 130μ. The esophagus, 640μ long, leads to the intestinal crura which run parallel to the side walls of the body and anastomose in the posterior end. The genital organs lie in the broad hinder end. The posterior testis is flattened antero-posteriorly and measures 1190μ in length by 732μ in breadth. It lies in the middle line of the body with its forward margin reaching to the vitelline duct. The anterior testis is spherical in form with a diameter of 835 to 878μ. It is removed anteriorly from the posterior end and lies adjacent to the intestinal crura. The ovary lies adjacent to the crural wall, opposite to the anterior testis and between the positions of the testes. It is spherical and has a diameter of 402μ. Between it and the posterior testis is found the relatively small receptaculum seminis.

The vitellaria are composed of numerous follicles which lie parallel to the body wall and between that and the intestinal crura; they extend from the region of the intestinal bifurcation to the posterior end where they are separated by a short interval. The numerous transverse uterus loops fill out the space between the crura and in the posterior half of the body overlap them. The genital pore is situated just posterior to the pharynx. The club-shaped cirrus pouch is small and does not reach the intestinal bifurcation. The eggs are numerous, elliptical in form and measure 102μ in length and 68μ in breadth. The ripe eggs hold a well developed embryo as can be recognized by the black eye spots in the miracidium.

The comparison of Arnsdorff with the figures and description of Stossich for closely related species show a striking similarity to *Cyclocoelum problematicum*. *Cyclocoelum vicarium* differs from this species, however, in the relative size of the worms, the extent of the cirrus pouch and the size of the eggs.

Habitat: Intestine	Host: *Arquatella maritima maritima*
Locality: North East Labrador	Date: September 14, 1906
Collector: Hantzsch	Königsberg Museum

NOTOCOTYLIDAE Lühe 1909

Of the monostome families which have up to this time been widely studied no other family is of greater interest than the Notocotylidae. It is in this family that the earliest records of the monostomes are found in *Catatropis verrucosa* (Frölich 1789) collected from the rectum of *Anas domestica*. These worms were classed by Frölich and Gmelin as Fasciola. Ten years later Zeder (1800) removed them to the genus Monostoma. They were later separated from the remaining monostomes by Diesing (1839) and placed in a new genus Notocotylus which genus remains as the type of the family. Although Diesing included this earliest known form in his genus Notocotylus, it has been found in more recent time by Odhner (1905) to be distinct from the Diesing type species, *Notocotylus triserialis*, and was removed to the new genus Catatropis which place it holds at present as type of that genus. A further study of *Notocotylus triserialis* Diesing by Kossack (1911) revealed its identity with *Monostomum attenuatum* Rud. 1809. Thus the species name becomes a synonym to *Notocotylus attenuatus*.

In regard to the early records of this family in America there still remains a question. Some authors notably Barker and Laughlin would place *Monostomum affine* Leidy 1858 as the earliest American record while others doubt this determination and still others reserve opinion on the matter. Barker (1916) questions the determination of Leidy and expresses the opinion that *Monostomum affine* Leidy belongs to the genus Notocotylus. While the description of Leidy (1858:110–112) is insufficient for an accurate determination of the systematic position of this species certain facts given in his description are distinct and seem sufficient to show that this worm is not Notocotylid in character. The length of *Monostomum affine* as given by Leidy is 6½ lines or 13.5 mm which is two and one-half to three times longer than any known species of this family. Likewise on the same basis the Leidy species is at least three times wider than the largest known Notocotylid. However, more important, intrinsic characters are the presence of a pharynx, an echinate penis and eggs prolonged at one pole only. In addition these worms were taken from the gall-bladder

and bile ducts of the muskrat while the Notocotylidae are normally inhabitants of the intestine and rectum. It is not impossible that a Notocotylid species may have ascended the gall-duct of this host and become modified and adjusted to the new conditions. Yet on the basis of the facts noted above the writer cannot agree with the opinion of Barker regarding the Notocotylid character of these worms.

More recently Hassall (Stiles & Hassall 1894) collected from *Arvicola riparius* and *Fiber zibethicus* taken in Maryland in 1892 specimens determined as Monostomum sp. and one year later from *Aix sponsa* and *Dafila acuta* worms also determined as Monostomum sp. On observation and study by the writer the specimens taken from *Aix sponsa, Dafila acuta* and *Fiber zibethicus* have been found to be distinctly different from forms previously described and on the basis given in a later section must be recognized as a new species. On account of the similarity to the immature stages of *Cercaria urbanensis* Cort it is believed to be the adult form of this species. The material taken from *Arvicola riparius* has been found to agree with *Notocotylus quinqueserialis* (Barker and Laughlin 1911). Other American records are those of Barker (1915, 1916) in which he records *Catatropis filamentis* from *Fiber zibethicus* taken in Nebraska and *Nudocotyle novicia* from the same host taken in the same region.

Additional records presented in this paper are *Notocotylus urbanensis* (Cort 1914) from the black and domestic swan taken at Golden Gate Park, San Francisco, California by John C. Johnson in February 1919 and *Paramonostomum echinum* nov. spec. from the intestine of *Fiber zibethicus* taken at Wray, Colorado by C. H. Gable, October 1916.

DIAGNOSIS OF FAMILY

Small monostomes tapering at both ends, posterior end broadly rounded, anterior slightly more attenuated. Generally with rows of papillae formed of unicellular dermal glands. Esophagus short, without pharynx; intestinal ceca with short diverticula, extending entire length of body. Genital pore median, except in Nudocotyle where it is distinctly lateral, usually near oral sucker. Cirrus sac elongate. Testes symmetrical, extracecal, near posterior end. Ovary between testes. Vitellaria lateral, anterior to testes. Uterine coils between cirrus sac and genital glands, transverse, regular, usually not extending outside intestinal crura. Eggs small with long polar filament on each end.

KEY TO SUBFAMILIES AND GENERA

1(5) Genital pore anterior median...Sub-family Notocotylinae..2
2(5) With ventral glands.....3
3(4) Ventral glands protrusible.....Notocotylus Diesing 1839
4(3) Ventral glands not protrusible.....Catatropis Odhner 1905

5(2) Ventral glands wanting.....Paramonostomum Lühe 1909
6(1) Genital pore marginal posterior without ventral glands....
.....:Sub-family Nudocotylinae ..7
Uterus in anterior body half.....Nudocotyle Barker 1916

The Notocotylidae are up to the present represented in North America by two species of Notocotylus and one species of each of the other genera in this family.

The Notocotylidae were subdivided by Kossack (1911) into two subfamilies; Notocotylinae including Notocotylus Diesing (1839) Catatropis Odhner (1905) and Paramonostomum Lühe (1909), and Ogmogasterinae represented by a single species *Ogmogaster plicatus* (Creplin 1829) Jägerskiold 1891. A third subfamily Nudocotylinae was created by Barker (1916) to hold *Nudocotyle novicia*. In this Barker would include *Barisomum erubescens* Linton (1910).

NOTOCOTYLINAE Kossack 1911

Small to medium sized Notocotylidae with thin cup-shaped body; two to five rows of prominent papillae on ventral surface. Genital pore median, near intestinal bifurcation. Cirrus pouch enclosing only a small part of seminal vesicle. Vitellaria well developed occupying a region posterior to middle portion of body anterior to testes and lateral to intestinal crura. Ovary and testes symmetrical, in extreme posterior part of body. Ovary between testes and separated from them by intestinal crura. Uterus regularly coiled, between intestinal crura.

Type genus Notocotylus. Other American genera Catatropis and Paramonostomum.

NOTOCOTYLUS Diesing 1839

Syn: *Notocotyle Diesing* 1850

The genus Notocotylus was formed by Diesing in 1839 to include *Fasciola verrucosa* Frölich, *Fasciola anseris* Gmelin, *Festucaria pedata* Schrank and *Monostoma verrucosum* Zeder. It was characterized by the author as follows: "Corpore oblonga-ovato, depressiuscula, antice parum attenuato, postice rotundato, ore terminali orbiculari; acetabulis suctoriis dorsalibus numerosis, serie triplici longitudinali; cirro longo spirali ventrali." In 1850 the author changed the name to Notocotyle with only a slightly modified diagnosis as follows: "Corpus oblongum depressum. Caput corpore continuum. Os subterminale anticum. Acetabula numerosa (24–50) juxta totam dorsi convexiusculi longitudinem treseriata sissilia, orbicularia, limbo callosa. Penis ventralis superus longi spiralis. Porus excretorius . . . . In avium intestinis crassis et coecis endoparasita!" Under this caption Diesing included his former genus Notocotylus. Altho Monticelli, Barker and others adhere to the more recent form of the name

the writer feels justified under Article 32 of the International Rules of Zoological Nomenclature in accepting with Kossack, Ward and others the older name Notocotylus.

This genus is up to the present represented in America by a single species *Notocotylus quinqueserialis* (Barker and Laughlin). Altho Barker (1916) would place *Monostomum affine* Leidy in this group, his determination seems to be unwarranted on the basis of the description of Leidy which shows distinct anatomical differences namely a small pharynx, echinate penis, a well marked excretory canal traceable to the beginning of the oviduct, and sub-pyriform eggs prolonged at one pole only. In addition to the anatomical differences *Monostomum affine* was found parasitic in the gall bladder and gall ducts of *Fiber zibethicus* whereas Notocotylus has been taken only from the intestine and ceca of the muskrat and water birds.

NOTOCOTYLUS URBANENSIS (Cort 1914)

[Figures 12, 14, 17, 18, 19]

Syn: *Monostoma* sp. Stiles and Hassall 1894

Medium sized worms 2.5 to 3.5 mm long by 0.5 to 1 mm wide, having three rows of ventral glands each row containing 13 to 14 glands. Oral sucker strongly muscular 112 to 153μ followed by a short esophagus without pharynx; intestinal crura provided with numerous short diverticula both externally and internally. Genital pore just posterior to intestinal bifurcation. From this point the cirrus pouch extends caudad to the end of the first body third or a little beyond this level. Vagina one-half the length of the cirrus. Usually about ten uterine loops anterior to the most anterior part of the vitellaria which as in other species of the genus lie lateral to the ceca and extend from the middle of the body to the lobed testes in the posterior end. The irregularly lobed ovary is situated between the testes and is separated from them by the crura. Eggs numerous possessing two long polar filaments. Eggs without filaments measure 20μ in length, and are approximately one-half that in width.

Habitat: Intestine	Host: *Dafila acuta*
Locality: Maryland	Collector: A. Hassall
Date: January, 1893	No. 5772 U.S.N.M.
Habitat: Cecum	Host: *Fiber zibethicus*
Locality: Maryland	Collector: A. Hassall
Date: June 23, 1892	No. 5769 & 5770 U.S.N.M.
Habitat: Intestine	Host: *Aix sponsa*
Locality: Maryland	Collector: A. Hassall
Date: August, 1893	No. 5771 U.S.N.M.

Notocotylus urbanensis agrees with *Notocotylus attenuatus* in size and form, and in the relative length of the cirrus pouch and vagina. With respect to the number of papillae in each row it conforms more closely

to *Notocotylus aegyptiacus;* it differs, however, from this species in the relative length of the cirrus pouch and vagina. In the position of the genital pore it agrees with *Notocotylus seineti* Fuhr. and in this respect it differs from other known species of this genus.

Stages in the Life History

Three collections No. 5769, 5770, and 5771 of the United States National Museum contain immature forms of this species. Collection No. 5771 contains both immature and sexually mature worms. The very young stages found in the two collections from the muskrat agree so well with the immature forms from *Aix sponsa* that it is impossible to differentiate the two forms and consequently they are taken to be identical.

The most immature specimens have apparently just burst out of the cysts since the pigmentation can be seen quite as perfectly as in most Notocotylid oercariae. The pigmentation in this species agrees generally with that described by Cort (1914) for *Cercaria urbanensis*. The pigmentation remaining is arranged around the lateral eye spots (Fig. 19) and the lateral pigmented lines extending from the eye spots to near the posterior end. Aside from this there is a very diffuse pigmentation throughout the entire body. From the time of encystment of the cercaria to the youngest stages at hand considerable change has taken place. The anterior eye spot has been lost and the general pigmentation as described above is generally much reduced as compared with the heavily pigmented *Cercaria urbanensis*. The locomotor pockets have been resorbed so that no trace of them exists in the youngest stages at hand. Development of the ventral glands is the most conspicuous change which has taken place. Figure 14 shows diagrammatically the youngest stage studied in which three ridges or keels are thrown out on the ventral side. The median one being about twice as high as the lateral ones which are ventral in position to the intestinal crura (Fig. 12). Along the median ridge the papillae altho only partially differentiated are clearly seen. The lateral ridges show indistinct irregularities which in section are clearly the beginnings of the papillae. No trace of the outer rows of papillae which occur in *Notocotylus quinqueserialis* have been observed. In more mature stages the ventral papillae are distinctly seen (Figs. 17, 19).

Faust (1918) stated that in the Monostomata the paired ceca are filled with a jell and are nonfunctional in the cercaria stage. In contrast to this the ceca in the youngest stages studied, which are of course well past the cercaria stages Faust studied, show that changes have taken place in this feature. The ceca in these stages show the intestine as a tube (Fig. 12) whose walls are surrounded by large nucleated cells. Totos in this stage of development also show distinct but small internal and external diverticula (Fig. 19).

The genital glands show little development over that of the cercariae. The ovary and testes are made out readily in the toto mount as well as the cords of cells which are to differentiate into uterus, vagina, vas deferens and cirrus. In more mature stages differentiation of the cirrus and vagina is well started so that the relative length of the two organs can be determined.

In the more mature specimens represented in figure 17 the genital glands have made a tremendous growth and appear very much as in the sexually active worm. The uterus, however, is less distinct and probably still non-functional. It is in this stage that the vitelline glands make their first appearance and here appear as single celled isolated follicles. The ducts of these follicles cannot be traced so that it is impossible to determine if the relation found by Faust (1918), namely that the vitellaria of Notocotylids are composed of five inner and three outer portions, obtains in this species.

Of the seven larval Monostomata described from North America, viz.

Cercaria hyalocauda Haldemann 1842
Glenocercaria lucania Leidy 1877
Cercaria urbanensis Cort 1914
Cercaria pellucida Faust 1918
Cercaria konadensis Faust 1918
Cercaria aurita Faust 1918
Cercaria robusta Faust 1918

the immature stages described above resemble more closely *Cercaria urbanensis* Cort (1914) than any other known monostome cercaria. Based on the similarity of the excretory system, of the genital organs, on the pigmentation and on the late differentiation of the vitellaria, no trace of which has yet been found in *Cercaria urbanensis*, it seems highly probable that these forms can be actually connected. Hence while demonstration of the life history by experimental methods has not at this time been given, it seems justifiable to accept *Cercaria urbanensis* as the larval form of this Notocotylid.

NOTOCOTYLUS QUINQUESERIALIS (Barker and Laughlin)

Syn: *Monostoma* sp. Stiles and Hassall 1894
Notocotyle quinqueseriale Barker and Laughlin 1911

Medium sized to large Notocotylids with wedge shaped body 2.5 to 4 mm long by 0.66 to 1.33 mm in maximum width which is found at the level of the ovary. Anterior end more or less pointed, posterior end rounded. Dorsal surface smooth, convex, ventral concave, unarmed but possessing five longitudinal rows of adhesive glands or papillae. Each row containing from 16 to 18 distinct wart-like projections. Mouth subterminal, spherical 200 to 450μ in diameter; esophagus short without pharynx. Intestinal crura irregular in shape and size with short internal and external diverticula. Genital pore between mouth and intestinal bifurca-

tion. Cirrus pouch extending from this point into the beginning of the second body third, being approximately one-third the length of the entire body. Vagina two-thirds the length of the cirrus pouch. The much lobed testes are situated in the posterior end, external to the intestinal crura. Ovary irregularly lobed, on a level with and between the testes, intracecal in position. Vitellaria extracecal, anterior to the testes, extending to the middle of the body.

Habitat: Intestine	Host: *Arvicola riparius*
Locality: Maryland	Collector: A. Hassall
Date: 1892	No. 5773 U.S.N.M.
Habitat: Intestine	Host: *Fiber zibethicus*
Locality: Baker Lake, Washington	Collector: H. E. Metcalf
Date: August 13, 1915	No. 15.120 Ward collection

The description of Barker and Laughlin while adequate states that the intestinal ceca are simple. A careful examination of the material at hand shows small, short diverticula both externally and internally throughout the length of the ceca. The writer has not had opportunity to study the material described by Barker and Laughlin.

CATATROPIS Odhner 1905

Body elongate, anterior and posterior ends usually equally rounded. Anterior half of ventral surface covered with three rows of non-protrusible papillae; median row set on a ridge or keel; lateral rows each containing 8 to 12 glands. Vagina strongly developed, usually as long as the cirrus pouch.

This genus was created by Odhner to hold *Catatropis verrucosa* (Frölich) which Odhner found to differ from Notocotylus in the character of the ventral glands, those of Notocotylus being protrusible while those found in *Catatropis verrucosa* were very much reduced, being in the form of a median ridge or keel in the median row and small embedded papillae or glands in the outer rows. It is similar to Notocotylus in its inner organization and differs from that genus in the fact that the ventral glands are not protrusible.

CATATROPIS FILAMENTIS Barker 1915

Syn: *Catatropis fimbriata* Barker 1915

Thin flat worms, gradually tapering anteriorly, 2.2 to 3.3 mm long by 0.56 to 0.7 mm wide at the level of the testes. Anterior half of the body covered with needle like spines arranged in oblique rows. Three rows of flattened papillae on the ventral surface, 12 to 13 in each row. Oral sucker spherical, 66 to 99μ in diameter. Esophagus 105 to 132μ in length. Pharynx wanting. Intestinal crura undulating. Testes two to four lobed, external to the intestinal crura. Ovary globular or oval 132μ long by 105

to 112μ wide, margin irregular. Shell gland ovoid, anterior to and a little larger than the ovary. Cirrus pouch tubular, elongate, extending to the beginning of the second body third. Prostate gland and cirrus covered with papillae. Vagina straight, muscular, as long as the cirrus pouch. Vitellaria external to the ceca, extending from the middle of the body caudad to the testes. Excretory bladder forked, opening to the exterior just dorsal to the posterior end. Eggs thick shelled, 20 to 22μ long by 11μ wide, having two long polar filaments, one at each end.

Habitat: Duodenum Host: *Fiber zibethicus*
Locality: Nebraska Collector: ?

PARAMONOSTOMUM Lühe 1910

This genus, created by Lühe to hold *Monostomum alveatum* (Mehlis) Creplin, is characterized by Lühe as follows: Body compressed, egg shaped, greatest breadth a little caudad from middle of body, posterior end broadly anterior tapering and pointed; anterior half of ventral surface thick set with short heavy spines. Ventral glands absent. Cirrus pouch weakly muscular. Vagina usually one-half length of cirrus pouch.

Type species: *Paramonostomum alveatum* (Mehlis) Crepl.

American representative: *Paramonostomum echinum* nov. spec.

Barker (1916) criticises the erection of a new genus on the basis of the absence of the ventral glands on the ground that the number of rows vary from two in *Notocotylus diserialis* Ssinitzin to five in *Notocotylus quinqueserialis* Barker and Laughlin. Yet the same author accepts the genus Catatropis of Odhner founded on the non-protrusible character of these same glands. There is apparently as much reason to accept the genus of Lühe based on their absence as that of Odhner founded on their non-protrusibility.

PARAMONOSTOMUM ECHINUM nov. spec.

Thin cup-shaped worms, 2 to 2.5 mm in length by 0.6 to 0.7 mm in maximum width which is found at the beginning of the posterior third of the body length. No ventral papillae have been found on these worms, the anterior half of the ventral surface being covered with heavy spines 5μ in length. These curve caudad and are thick set according to the definite pattern shown in figures 13 and 16. Mouth terminal, spherical, 102 to 125μ in diameter, followed by a short esophagus which bifurcates to form the intestinal crura; these follow an undulating course to the posterior end of the body where they end blindly. Crura provided with short but definite internal and external diverticula. Genital pore situated just posterior to the intestinal bifucation. Cirrus pouch extends from this point into the beginning of the second third of the body. Vagina one-half as long as the cirrus pouch. Prostate gland and cirrus without papillae.

Testes four lobed, extracecal, lying at the same level in the posterior end of the body. Ovary between the testes and separated from them by the intestinal crura. The three to four lobed ovary is usually elongated anteroposteriorly. The uterus as in other members of this genus is coiled transversely between the crura and extends from the level of the ovarian complex to the posterior end of the cirrus pouch at the beginning of the second body third. The vitelline glands occupy an extracecal position and extend from the testes to the middle region of the uterine coils which is found in the caudal portion of the second body third. Eggs numerous, medium thick shelled, 20μ in length and approximately twice as long as wide. They possess a long polar filament at each end.

Habitat: Intestine	Host: *Fiber zibethicus*
Locality: Wray, Colorado	Collector: C. H. Gable
Date: October 30, 1916	No. 21.91 Ward collection

NUDOCOTYLINAE Barker 1919

Small cup shaped Notocotylidae with thick bodies, without ventral glands. Genital pores separate, ventral, lateral, in posterior half of body. Cirrus pouch pear-shaped, enclosing small portion of seminal vesicle. Vitelline glands strongly developed compact masses, lateral to ceca and anterior to testes. Uterus in transverse folds, in anterior half of body, extending laterally over intestinal crura.

Type genus: Nudocotyle Barker 1916

Barker would include Barisomum Linton 1910 in this sub-family. This is a doubtful decision since in the genus Barisomum the genital pore is in the anterior body third and the shell gland lies posterior to the ovary. It possesses in fact certain Notocotylid characters but conforms more closely to the Pronocephalidae than to the Notocotylidae in the position of the genital pore, and the character and position of the genital glands.

NUDOCOTYLE NOVICIA Barker 1916

Small thick oval worms, 709 to 899μ in length; 500 to 657μ in breadth. Anterior end tapering gradually, posterior markedly truncate. Dorsal surface strongly convex, ventral concave. Body smooth, devoid of ventral papillae or spines. Oral sucker subterminal, spherical 50 to 65μ in diameter; pharynx wanting; intestinal ceca undulating but without diverticula. Male and female genital pores separate, ventral, lateral, in beginning of posterior body third. Cirrus pouch large, club-shaped, about one-third of body width in length. It lies transversely and median in anterior portion of posterior body half. Cirrus without spines. Testes extracecal in position, lying in same level in posterior fifth of body, frequently 2 to 5 lobed. Ovary elongated, convoluted or lobed, in extreme posterior end of body between testes and separated from them by intestinal crura. Shell gland

compact, anterior to ovary. Laurer's canal and receptaculum seminis were not observed by Barker. Eggs oval, twice as long as wide, 20 to 24μ long 10 to 13μ wide. With long polar filament on each end about five times as long as egg itself.

HERONIMIDAE Ward 1917

This family was created by Ward (1917) to hold the two aberrant genera Heronimus MacCallum (1902) and Aorchis Barker and Parsons (1914). Ward called attention to the close resemblance of the two forms and suggested that they might prove to be identical. He characterized the family as follows: "Moderate sized monostomes with thick, elongate, soft body, slightly flattened, tapering toward both ends. Oral sucker weak; pharynx large; esophagus short or absent; ceca simple, narrow, extending to posterior tip but not united. Vitellaria compact, tubular. Uterus with four longitudinal regions; genital pore ventral to oral sucker, near anterior tip. Testis tubular, small; copulatory apparatus poorly developed. In lungs of turtles, northern North America."

One year later (1918) the same author restated the family diagnosis with the following addition: "Vitellaria compact tubular, shaped like an inverted V. Testes tubular, lobed or with short branches, united into a V-shaped organ with the apex anteriad," and again stated that the two forms probably belonged to the same genus. About a year later Stunkard (1919) presented a paper in which he showed that the apparent difference in the two forms was due largely to the partially diagrammatic figure of MacCallum (1902) and to the discrepancies in the description of Barker and Parsons (1914) and that the two forms are identical, thus not only belonging to the same genus as suggested by Ward but representing a single species, *Heronimus chelydrae* MacCallum.

HERONIMUS CHELYDRAE W. G. MacCallum 1902

Syn: *Aorchis extensus* Barker and Parsons 1914
Aorchis extensus Ward 1917
Monostoma sp. Stiles and Hassall 1894

The genus was created by MacCallum (1902) to include worms collected from the lungs and bronchi of *Chelydra serpentina*. The genus stands according to MacCallum "in many respects far apart from the other genera," especially in the position and nature of the genital opening, in the complicated structure and course of the uterine tract, in the unusual formation of the yolk glands, in the presence of but one testicle and in the position of the excretory pore. The genus may be recognized by the following diagnosis: Medium to large monostomes with semicyclidrical body tapering slightly towards both ends; strongly muscular. Mouth

opening terminal, oral sucker small, pharynx weak but distinct. Esophagus very short; intestinal ceca simple, ending blindly in the extreme posterior of the body. Genital pore inconspicuous, median, ventral to the pharynx. Ovary situated in the anterior one-fourth of the body, lateral, usually intracecal; shell gland smaller than the ovary and posterior to that organ. Receptaculum seminis present, usually about two-thirds as large as the ovary. Laurer's canal absent. Uterus, except for the four longitudinal loops, coiled around the intestinal crura from the level of the ovary to the posterior end of the animal. Vitelline gland a coarse, compact U-shaped, closed tubular structure, dorsal to the intestine. Testis U-shaped, closed portion cephalad, about one-fourth the body length from the anterior end. The tubular, irregularly lobed testicular mass extends caudad to a level about one-eight the body length from the posterior end. Protrusible, non-muscular cirrus present. Excretory pore median, anterior, dorsal to the pharynx. Eggs large, ovoid, thin shelled, containing fully developed miracidia in the metraterm.

The anatomy of this form is well described by MacCallum (1902) and Barker and Parsons (1914, 1917), and with the additions and corrections of Stunkard (1919) calls for no further anatomical discussion here.

The writer has been given an opportunity to examine the type specimen of this species deposited in the United States National Museum and can verify the statements of Stunkard on the specific identity of the two species.

MacCallum reported the original material from *Chelydra serpentina* taken in the Grand river at Dunville, Ontario, Canada. Barker and Parsons (1914) report from *Chrysemys marginata* taken in Lake Emily, Minnesota, and the Mississippi river and later (1917) in the same host taken in the Mississippi river near Fairport, Iowa. At this time they call attention to the distribution in Illinois.

Ward (1917) reports this species from "various turtles" taken in Michigan, Indiana, Illinois and Nebraska. Stunkard (1919) collected this species from *Chelydra serpentina* taken in Illinois, Ohio, North Carolina and Texas; in *Chrysemys marginata* taken in Iowa, Illinois, Missouri and Kentucky; in *Pseudemys elegans* and *Malacoclemmys geographicus* in Illinois; *Aromochélys odoratus* and *Kinosternum pennsylvanicum* in North Carolina. The specimen listed by Stiles and Hassall (1894:253) as "Monostoma sp.—Chelonia gen. sp. (bronchi)—Illinois-Forbes-Leidy" belongs here.

The writer has found this species in *Chelydra serpentina* and *Chrysemys marginata* taken in the drainage ditch at Urbana, Illinois; in *Chrysemys marginata* taken in the Mississippi river near Fairport, Iowa; in *Graptemys geographicus* taken near Chicago, Illinois; in *Chelydra serpentina* and *Chrysemys marginata* taken in Minnesota and in *Kinosternum pennsylvanicum*, *Kinosternon odoratus*, and *Chrysemys picta*, a new host, taken in North Carolina.

While this species was reported by MacCallum as "not by any means a constant parasite," he having found it in only one host infected of a number examined, more recent data show this worm to be rather constantly present. In seven specimens of *Chrysemys marginata* collected in the summer of 1911 from Lake Emily, Minn., Barker and Parsons found five infected, one of them yielding thirteen worms from both lungs. The same authors (1917) found that female turtles were more than three times as heavily infected as males, Stunkard (1919) from the examination of "about three hundred turtles" reports the heaviest infection in one host as six. On an examination of "more than fifty turtles" he found no difference in the relative infections of males and females. The writer has examined one hundred and two hosts of six different species and of these forty-four showed infection with these worms. The highest percentage of infection for any species was found in *Cinosternum pennsylvanicum* from North Carolina in which 34 out of 45 specimens or approximately 75 percent were infected. The highest number of individuals from a single host of this species was eleven while a single individual of *Graptemys geographicus*, and the only one of eighteen which showed infection, carried twelve worms in both lungs.

During the past four years the writer has had opportunity to examine more than one-hundred turtles as stated above. It was noted early in the investigation that the collections made in different seasons showed no striking difference in percentage of infection. It was then undertaken to determine if possible the length of life of this parasite in the definite host. It is generally understood that most intestinal paraties have an annual cycle and depend on this for continuity of the species. However, data on this point seems lacking in this group. The work on *Heronimus chelydrae* consisted in the examination of a number of turtles collected in the same region, Raleigh, North Carolina, at various seasons of the year.

Some of these dissected on arrival showed relatively heavy infections, others which were kept in the laboratory aquaria for periods of six, twelve and eighteen months still carried infection, and a single specimen of *Chelydra serpentina* which had been kept in an aquarium for more than three years yielded two specimens of *Heronimus chelydrae* and a single nematode, probably *Camallanus americanus*. As was stated above hosts examined when taken, usually carry intestinal forms in addition to the lung fluke already mentioned, while those which have been kept in aquaria for a period of six months or more show a marked reduction in the number of the intestinal forms. There is no apparent change in the number of the lung flukes present.

Little is known regarding the condition of parasites during hibernation of the host. Blanchard (1903) records that hibernating marmots do not contain any intestinal parasites. Ward (1909) reports observations carried out on the frog, *Rana virescens*. In this he says that parasitic infection increases steadily up to hibernation, and does not decrease during the latter

period; that the parasites reach the climax of sexual maturity soon after the host emerges from the winter quarters. They discharge their eggs and pass out from the body of the host soon after the time of spawning, and at the close of this period the hosts are relatively free from infection.

Observations of the writer verify the sexual inactivity of the parasite *Heronimus chelydrae* during the early part of the winter and the copious discharge of mature miracidia in early spring. On the other hand these turtles did not become free from infection at any time during the period of the experiment. It must be kept in mind however that the turtles used were not subject to natural conditions, i.e., no opportunity was afforded for hibernation and no eggs were deposited during this time. That trematodes adapted to partially closed cavities can live longer than for a single reproductive phase is evident, since in the instance reported above in which the host has been kept for a period of more than three years, the two parasites found were sexually mature, and were producing large quantities of ripe eggs when the host was examined; this is true also in one other case in which the host was kept for more than eighteen months.

COLLYRICLIDAE Ward 1917

This family was created to hold the genus Collyriclum of Kossack and is circumscribed by Ward as follows:

"Small to moderate sized monostomes with discoidal compressed, not muscular body, broader than long. Oral sucker weak; pharynx present; ceca simple, long, capacious, not united. Genital pore ventral near center of body. Vitellaria follicular, scanty, antero-lateral; ovary much lobed, symmetrical. Uterus posterior, in irregular coils which show an antero-posterior tendency, terminal region enlarged. Testes oval, symmetrical, behind ovary. Eggs very small. Adults parasitic in dermal cysts on abdominal surface of the skin of birds."

In the light of our present knowledge of these forms the family diagnosis must be modified with respect to the condition of the testes. Tyzzer (1918) has shown the testes of the American species to be irregularly lobed and not oval as described for the European species, *Collyriclum faba* by both Kossack (1911) and Jegen (1917). The writer has examined a number of specimens of *Collyriclum colei* Ward and has found the observation of Tyzzer stated above to be correct.

Type and only genus: Collyriclum Kossack 1911.

American representative: *Collyriclum colei* Ward 1917

COLLYRICLUM COLEI Ward 1917

Syn: *Monostoma faba* Cole 1911
Collyriclum faba Tyzzer 1918

Diagnosis: Small hemispherical worms, 4 to 5 mm in length and breadth by 3 mm thick. Cuticula covered with spines 35μ in length, arranged in groups which form rather regular rows around the worm. Mouth terminal

or slightly dorsally placed, surrounded by a muscular sucker 220μ long by 375μ wide. Pharynx smaller 140μ long by 125μ wide, adjacent to the sucker, followed by short esophagus which bifurcates to form the large voluminous simple intestinal crura; these end blindly at the end of the middle body third. Genital orifice ventral, near center of body. Testes near the ends of the crura, lobed, the main portion pear-shaped. Ovary in intestinal bifurcation, three branched, each division containing from 5 to 10 lobes. Vitellaria well developed, imperfectly symmetrical with 5 to 7 groups on the left and 7 to 9 on the right. Uterus much coiled, generally in the posterior half showing a tendency to antero-posterior coiling. Eggs small, 19 to 22μ long by 10 to 12μ wide, containing in the end portion of the uterus a fully formed miracidium.

The anatomy of these worms has been so thoroughly discussed by Tyzzer (1918) for the American species, and by Kossack (1911) and Jegen (1917) for the European species that it does not seem necessary to enter into a detailed discussion here. I desire instead to give a comparison of the two forms since Tyzzer found reason based largely on the inconsistency of Kossack's description and figures to declare the American material identical with that found in Europe.

Ward (1917) after examination of the material reported by Cole (1911) as *Monostoma faba* pointed out distinct differences between this and the European form described by Kossack (1911). The following is his statement, "As a cause of an epidemic among sparrows at Madison Wisconsin, Cole (1911) reported under the name of *Monostoma faba* a trematode that in reality differs distinctly from the European species. The form of the ovary, the extent of the vitellaria, the dermal spines, and other details of structure disagree with the recent description of Kossack who, moreover, assigned Rudolphi's species." [erroneously attributed to Rudolphi, really Bremser (1831)] "to his new genus Collyriclum. The American form constitutes a new species in this genus and to it the name *Collyriclum colei* may be given."

One year later (1918) the same author restated the differences in the two species as follows: "These specimens differ clearly from the European form in numerous minor details, such as ovary, yolk glands, dermal spines, etc., and demand recognition as a distinct species under the name given here."

Tyzzer (1918) made a comparison of the two forms based on Kossack's description of *Collyriclum faba* and concluded that the two species were identical despite certain distinct differences which he explained away on the basis of the discrepancies between Kossack's description and figures. The work of Jegen (1917) which reached America after Tyzzer's had appeared verifies in a large measure the description of Kossack and leaves little doubt that the American material is distinct from *Collyriclum faba*. The following is the diagnosis of this species as given by Jegen: "In Cysten

Table I. Comparison of *Collyriclum faba* with *C. colei*
After Tyzzer, 1918, with additions from Jegen, 1917

	European Material *Collyriclum faba*	American Material *Collyriclum colei*
Shape	Somewhat hemispherical.	The same. Minor additional points noted.
Size	4.2—4.8×4.5—5.46 mm Jegen from *P. domesticus* 4.4—5.2×6—5.4.	4.1×4.8×2.9 mm.
Mouth	Ventrally placed.	Dorsal to margin of body. In flattened specimens appears ventral from over-riding of larger dorsal surface.
Uterus	Similarly arranged in both.	
Intestine	Identical in form.	and extent.
Vitellaria	Symmetrical, each with seven rarely six or eight, follicle groups.	Not perfectly symmetrical, five to seven on left and seven to nine follicle groups on right side.
Ovary	T-shaped, each of three divisions with four or five branches. Jegen reports 5–7 lobes.	Of similar form, each division from 5–10 lobes.
Testes	Oblong or saber-shaped.	Showing three or more large processes and other minor irregularities, and curved over the blind ends of the intestine. In gross specimens seen only in part, appearing oblong or saber shaped. Measurement not feasible.
Genital orifices	General agreement in both.	
Oral sucker	0.204,5 to .441, 2 mm. Jegen, 0.3 to 0.45 mm.	Average, 0.219,8×0.375,3 mm.
Pharynx	0.129,1 to 0.193,7 mm. Jegen, 0.113 to .145 mm.	Average 0.140×.124,5 mm.
Spines	"Arranged in lines, with the individual spines apparently widely separated from one another." Up to 35μ in length. Jegen: in groups of 4 to 8, 28 to 35μ.	Set in annular rugae; maximum distance separating latter, .45 to 53μ. Up to 35,5μ in length. Average dorsal, 27,9μ long.
Ova	19,8×9,7μ.	19 to 21,4×10,6—11,6μ. Average 20,5×11,3μ.

zu zweien vorkommende Trematoden. Körperform annähernd rund. Dorsale Fläche stark gewölbt, ventrale weniger gewölbt bis flach. Haut mit Stacheln besetzt, die in Gruppen von vier bis acht Einzelstacheln stehen. Mundsaugnapf endständig. Darmschenkel einfach und zwei Drittel der Breite des Körpers einnehmend. Bauchsaugnapf fehlt. Terminal am Hinterende eine muskelreiche Partie, die bei der Fortbewegung als Saugorgan Wirkt. Genital pori auf einer papillenartigen Erhöhung, median etwas vor der Körpermitte gelegen. Excretionsblase birnförmig und bedeutend über die Mitte hinausreichend. Dotterstöcke aus zwei seitlich gelegenen Follikelgruppen (7) bestehend. Hoden dorsal, den Darmschenkelspitzen genähert. Keimstock vor den Hoden, im ersten Körperdrittel, aus drei lobösen Gruppen bestehend. Schalendrüse unmittelbar neben und unter dem Keimstock. Laurersche Kanal vorhanden. Receptaculum seminis fehlt. Uterusschlingen hauptsächlich im hinteren Körperteil. Eier ohne Filamente, mit scharf abgesetztem Deckel und einer kleinen, seitlichen Spitze am entgegengesetzten Pol, sehr zahlreich."

Because of the distinct differences shown by Tyzzer his table is incorporated with Jegen's corrections to Kossack's description of *Collyriclum faba*. It is printed on preceding page of this paper.

A study of the table shows clearly that the species in question differ with respect to the asymmetry and extent of the vitellaria and the form of the testes. In regard to the agreement of the American material with Kossack's description Tyzzer says: "that the American material agrees very closely in most respects with Kossack's description, there being similarity of size and shape, in the appearance of the alimentary canal and uterus, and in the position of the genital orifices. The measurements of the oral sucker, pharynx, esophagus, spines, and ova correspond rather closely, and such differences as occur appear to be within the limits of species variation."

Regarding the grouping of the spines Kossack (1911:574) "Die Haut ist mit Stacheln bedeckt, die in regelmässigen Reihen angeordnet sind. Die einzelnen Stacheln sind ziemlich weit voneinander entfernt und durchschnittlich 0.035 mm lang." Jegen describes the spines as being arranged in groups in rows. Four to eight spines in a group, and says, "Kossack erwähnt (S. 574) dass die Stacheln in regelmässigen Reihen angeordnet seien. Ich glaube nun nicht, wie Odhner dies ausspricht, dass er die Stachelgruppen übersehen hätte, wenn sie überhaupt in seinem Material vorhanden waren. Vielmehr liegt die Möglichkeit vor, dass er ein Entwicklungsstadium vor sich hatte, bei dem die Gruppen noch nicht vollständig gebildet waren."

Tyzzer calls attention to the ovary which he says "presents more lobules than was noted by Kossack." Jegen states that the ovary is very strongly lobed and found: "An jedem der drei Aste sitzen fünf bis sieben

solcher einzelner Knollen." Tyzzer states further that "the basis for differentiation of an American species at the present time appears therefore to be rather inadequate." That he is dealing with the same species as that reported by Cole (1911) and later named *Collyriclum colei* by Ward (1917) cannot be doubted and according to his statement his material "is undoubtedly of the same species."

Although Tyzzer failed to find any difference which would warrant a second species of Collyriclum the present investigation has shown that except in minor detail the work of Jegen agrees with that of Kossack, and on the basis of the descriptions of these investigators the American material is distinct from *Collyriclum faba* in that the testes are lobed and in the asymmetry and extent of development of the vitellaria. It is impossible to explain away these differences either as "artefacts in preservation" or as "individual variation," nor is it probable that both Kossack and Jegen have overlooked these features. On the basis of these difference the American material must be recognized as a distinct species under the name *Collyriclum colei* Ward.

A preliminary study of specimens of *Collyriclum faba* secured by Professor Ward bears out the description of Kossack and Jegen as well as the conclusions of the writer drawn from the study of their papers and comparison with American specimens of this genus. A more thorough study of the European material is not feasible at this time but is anticipated at an early opportunity.

REMARKS ON THE LIFE HISTORY

The life history of *Collyriclum faba* is doubtfully known. Tyzzer gives a careful description of the development of the egg of *Collyriclum colei* from the time of fertilization to maturity in the end portion of the uterus. Regarding the mature eggs he says "The eggs stored in the terminal portion of the uterus evidently contain miracidia, the morphological features of which are not clear in fixed material owing to imperfect preservation and shrinkage." He continues with a description of the "hair-like" structures which have been distinguished. This adds evidence that a miracidium is present.

The work of Jegen (1917) which is an attempt at the life history of *Collyriclum faba* differs radically from the statements of Tyzzer in that he finds the eggs contain two embryos which are not miracidia but young trematodes; these need only to be incubated in the intestine of the host that they may break out of the egg shell and freed with the excrement, may wander into the feather follicle. He found also cysts (Dauercyste) which after a longer period of incubation break open and the worm enters the follicle of a feather. Jegen summarizes his work as follows: "Die Eier von *Collyriclum faba* werden durch den Wirt mit dem Parasiten aufge-

pickt und gelangen in den Vogeldarm, wo die Embryonem ausschlüpfen. Mit den Excrementen werden letztere ins Freie befördert, wo sie, sofern die Möglichkeit zur Infektion vorhanden ist, direkt in die Federfollikel der jungen Vögel einwandern. Im andern Fall bilden sich Dauercysten, die nach längerer Entwicklungsruhe such auflösen und den eingeschlossenen Organismus frei lassen, so dass er ebenfalls in die Federfollikel einwandern kann." This summary of Jegen is supported by experimental evidence gained by incubation of the eggs in a portion of the intestine of an infected bird as well as by numerous attempts to incubate the eggs which had not passed through the intestine of the host altho he says these gave negative results. The "Dauercysten" he found in excrement of infected birds, which was dried by exposure to air, and at other times in the nest and on the feathers of young sparrows.

The outline of Jegen gives essentially a direct development which omits the parthenogenetic stages observed in all cases where the life history of digenetic trematodes is known. Observations of the writer support the view of Tyzzer that a miracidium is present in the mature egg in the uterine egg sac. The fully developed miracidium shows well developed germ balls. This is in direct contrast to the findings of Jegen who says that the embryo contains two well developed germ balls with numerous others which disappear later in course of development. Jegen found that the eggs would develop only in the intestine of the host and when fed to uninfected birds empty egg shells and embryos were found on the second and third day. He neither states nor demonstrates that these experimental birds became infected with the adult parasites.

The work of Jegen dealing with the life history of Collyriclum is full of gaps. The life history as given is bridged over by supposition. The infection of the sparrows by feeding of eggs is not demonstrated, only the presence of embryos which may well be miracidia. Jegen does not demonstrate beyond doubt that these cause the formation of the cysts in the sparrow. The "Dauercysten" which he says infect directly the host based on his experiment of the dried excrement certainly serve to protect the parasite from dessication until it can reach the intermediate host; nothing indicates whether this be a miracidium or another infective stage; and the periodicity of occurrence of the adult parasite in correlation with a rainy season tends to show that the former is the correct interpretation.

The work of Jegen is apparently a misinterpretation of the life history and leaves much to be done in order to demonstrate the facts. The only clear contribution of this author to the life history of this form lies in the discovery of the "Dauercysten" which he apparently misinterpreted. Many more extensive and careful experiments must be carried out in order to demonstrate conclusively the complete life history of this form.

Species Inquirendae

CLINOSTOMUM (?) INCOMMODUM (Leidy)

Syn: *Monostomum incommodum* Leidy 1856
Distoma oricola Leidy 1884
Distomum incommodum Leidy 1890
Monostomum incommodum Leidy 1904

Monostomum incommodum is described by Leidy as follows: "Body compressed, above convex, below concave, sides parallel anteriorly convex, posteriorly angularly convex. Head continuous with the body, obliquely truncated. Mouth round, surrounded with a wide circular lip which is emarginate below. Male generative aperature? communicating with a hemispherical cavity (acetabulum?) one-fourth the length of the body from the head. Length 9 lines, breadth 1½ lines.

Habitat: Fauces — Host: *Alligator mississippiensis*
Locality: Florida — Collector: J. W. Bailey
Date: Previous to 1856

Leidy (1890) places this species as *Distomum incommodum* and as a synonym of this species his *Distoma oricola* from the mouth of *Alligator mississippiensis*. On the basis of the later determination of Leidy (1890) his description of *Distoma oricola* is here included for the purpose of comparison and as evidence for the disposition of *Monostomum incommodum*.

Distoma oricola Leidy 1884

"Body elongated elliptical, moderately wider and thicker posteriorly and ending in a blunt, angular extremity, convex dorsally and flat ventrally, unarmed, smooth or minutely wrinkled transversely. Mouth subterminal, and enclosed with a reniform lip succeeded by a linear annulus. Acetabulum large, globular, included at the anterior fourth of the body, and opening ventrally by a conspicuous central aperature. Generative orifice ventral, at the posterior fourth of the body. Length, 15 to 20 mm; breadth, 3 mm. Eight specimens obtained from the mouth of the alligator, *A. mississippiensis*, in Florida, by Mr. Stuart Wood."

Pratt (1902) surmises that this species is allied to the genus Clinostomum. This view is supported by Ward (1918). Then if, according to this view the determination of Leidy, that *Distoma oricola* is a synonym of *Monostomum incommodum* which he determined later (1890) as a Distome, *Distomum incommodum*, be accepted, *Monostomum incommodum* is likewise allied to the genus Clinostomum.

MONOSTOMUM ORNATUM Leidy 1856

Syn.—*Monostomum ornatum* Brandes 1892
Monostomum ornatum Braun 1893
Monostomum ornatum Diesing 1858
Monostomum ornatum Monticelli 1892
Monostomum ornatum Stafford 1902

This species was described by Leidy as follows:

"Body slightly compressed ovoidal, anteriorly broad; yellow variegated with brownish red. Mouth infero-terminal, acetabuliform, transversely oval. Penis conical, protruding a short distance below the mouth. Female aperture a short distance below the penis. Length 1 to 1½ lines, breadth ½ to ¾ line, thickness ¼ to ½ line."

Habitat: Body cavity — Host: *Rana pipiens*
Locality: Philadelphia — Collector: H. W. Warren

Stafford (1902) questions the determination of these worms and conjectures that they belong either to the genus Haematoloechus sp. which is commonly found in the lungs of frogs or to *Dist. quietum* or *Cephalogonimue amer.* and have been liberated in the first case from the lung and in the other cases from the small intestine of the host. He inclines to the former view "on account of the ease with which the small ventral sucker may be overlooked and the readiness with which worms may be freed from the lungs without observation." He adds that, "it is unlikely to be *Distomum quietum* from the position of the genital openings" and that "it could scarcely have been *Dist. retusum* (*Ceph. amer.?*) since he reports it also in the same paper although he does not describe it there but in an earlier number."

In regard to the habitat of *Monostomum ornatum* Stafford says that "of the hundreds of frogs I have examined I have never yet found a Trematode free in the body cavity and I doubt if anybody else has ever obtained one that did not first get there by the accidental cutting or tearing of some other organ."

The above assumption of Stafford that trematodes do not occur free in the body cavity of frogs appears to be doubtfully correct. Osborn (1922) and Cort (1913) report encysted Clinostomum in the body cavity. The writer in examination of numbers of frogs has been able to observe these and has several times found some of these worms out of their cysts and free in the body cavity. These frogs were opened most carefully and worms that might have been freed by the cutting of the body wall could not have found their way to remote parts of the cavity in the time consumed by the operation and examination. On the other hand it is hardly probable that the dozen specimens recorded should escape from the lungs unnoticed as suspected by Stafford and none be left to show the normal habitat. However, as Stafford has noted and as was stated above, the worm could scarcely have been *Distomum retusum* (*Cephalogonimus americanus?*)

since it is recorded in the same paper. Stafford, however, has failed to note that Leidy recorded also in this same paper *Distomum variegatum* from the lungs of *Rana pipiens* which he also describes in the same "earlier number" in which he describes *Distomum retusum.* Hence Haematoloechus is ruled out as well. From the habitat of these worms the writer suspects that it may possibly be a larval stage of a species of Clinostomum. The description is so meager that it is impossible to place it in any definite manner.

MONOSTOMUM SPATULATUM Leidy 1858

Syn: *Monostomum spathulatum* Diesing 1859

The following description given by Leidy includes the only available data. "Body flat, oblong ovate, narrowing anteriorly, obtuse posteriorly, color white, with brown tortuous lines indicating the course of the oviduct. Mouth acetabuliform, circular. Testes three, alternating on each side posteriorly with the oviduct. Ovaries on each side finely lobulated. Generative aperture small a short distance behind the mouth. Penis undistinguishable. Length 3–4 lines: breadth ½ line.

Habitat: Gall-bladder. Host: Fish species unknown
Locality: Eastern U. S. Collector: Jeffries Wyman

MONOSTOMUM AFFINE Leidy 1858

Syn: *Notocotyle*(?)*affine* Barker 1916

Leidy described this species as follows: "Body spatulate narrowest anteriorly, flat; posterior end obtuse, with an excretory orifice communicating with a well marked canal traceable as far forwaid as the commencement of the oviduct. Mouth round, oral acetabulum small, followed by a smaller pharyngeal bulb. Intestine simple, traceable on each side to the posterior end of the body. Testes four, posterior to the position of the distended oviducts. Ovaries finely lobulated, situated on each side external to the position of the intestine; oviduct transversely tortuous and distended with brown ova. Penis ensheathed, long, tortuous, echinate. Generative aperture small, acetabuliform. Ova oval and prolonged at one pole, or sub-pyriform. Length of body 6½ lines; breadth 1 line."

"Four specimens were obtained by Dr. J. N. Corse from the bile-ducts and gall-bladder of the muskrat (*Fiber zibethicus*). Closely allied to *M. hippocrepis* Diesing, but has no trace of the horse-shoe like collar to the head."

As is stated previously in this work the suggestion of Barker appears to be a misfit on the basis of the pharynx, the echinate penis and the undivided excretory canal which Leidy says is traceable as far forward as

the beginning of the oviduct. These characters are fundamental differences such as are used to separate families and groups and on the basis of these differences the supposition of Barker (1916) seems untenable.

MONOSTOMUM ASPERUM Vaillant 1863

Syn: *Monostomulum aspersum* Brandes 1892
Monostomum aspersum Pratt 1902

Vaillant described this species as follows: 1.4 to 1.9 mm long by 0.94 mm wide, elongated, both ends rounded; dorsal surface convex, ventral flat; cuticula in the anterior 5/6 densely covered with small spines regularly spaced and arranged in alternating rows. Mouth opening round. The digestive system composed of muscular esophageal bulb, followed by a long esophagus which extends to the middle of the body where it bifurcates to form the two ceca which extend to the level of the excretory bladder. The excretory bladder forms a semi-oval sac, which occupies the posterior end of the animal. The genital organs are between the excretory bladder and the ends of the intestinal ceca. The male organs are composed of a curved spinous penis, with a testicle, a vesicula seminalis and a deferent canal. The female organs are wanting or in some individuals incompletely developed and consist only of a granular cell mass.

Found in transparent sub-epidermal cysts of *Siren lacertina*.

In a later paper the same author (Vaillant, 1863a:347) expresses doubt in regard to his interpretation of the sex organs which he says appear to be only poorly developed.

On the basis of the descriptions of Vaillant, Brandes considered this as a larval form but attempted no further indication for the disposition of the species. Monticelli (1892) enumerates it without any attempt to determine its rightful place. Pratt assigns to it the same place as did Brandes.

Both accounts of this worm are such that the inference may be readily drawn regarding its larval nature. Neither account gives evidence of any individual in a sexually mature state. The sex organs are poorly developed and no mention is made of a uterus or of eggs which would indicate sexual maturity. The exceptional habitat assigned to this worm by Vaillant which he says is comparable to that of *Monostomum faba* Bremser is not so rare in the light of the present knowledge of the life histories of distomes and is quite in contrast to what is now known of the monostome life history. Many distomes are known to pass a portion of their life cycle encysted in the skin and superficial layers of the body, while no such stage has yet been found in the cycle of a monostome. The description of Vaillant as well as his figures are so inadequate that it would be hazardous to speculate on the systematic position of this form more than to say on the basis of the digestive system the cuticular spines and what has been given regarding the genital glands that it is probably the immature stage of a distome.

MONOSTOMUM AMIURI Stafford 1900

This trematode taken from the swim bladder of *Amiurus nebulosus* by Stafford, is described by him as follows: "About 5 mm long and 2.25 mm broad much flattened and is broadest in its posterior two-thirds, the anterior third narrowing towards the mouth-sucker. The living animals are very soft bodied, inactive creatures."

"The integument bears a cuticle and is apparently very thin the subcuticular and glandular parts seem to have a similar structure to the same parts of the Distomes with which I am most acquainted. The intestinal system begins with the mouth whose thick muscular walls form the oral sucker. Following this is a muscular pharynx and a narrow esophagus which gives rise to two lateral intestinal ceca, extending as broad tubes to near the posterior end of the body where they end blindly."

"The posterior excretory bladder unpaired."

"The reproductive system is of the usual complex type. Each individual dioecious. The testes are situated most posterior in the body, between the median expulsion tube of the excretory system and the ends of the intestinal ceca, the vasa efferentia rise out of their anterior ends and proceed, by a direct course, to near the middle of the animal where they meet in the vesicula seminalis. This runs forward and opens by a muscular penis on the ventral surface of the worm, about one-third from its anterior end. The ovary is located a little behind the middle of the animal. The uterus filled with eggs occupies most of the posterior two-thirds of the body and opens by a bulbous vagina immediately behind and to the right of the penis. The two lobular yolk glands lie outside of the forked intestine and extend from the level of the genital openings to the hind end of the animal. A longitudinal yolk duct receives the yolk cells from the numerous follicles on each side and conducts them, by a transverse tube in the region of the ovary, to a yolk reservoir that communicates with the oviduct close by the shell gland. The egg is 45 by 24μ in size and its blunt broader end is provided with a short hooked filament."

The description and figure of Stafford shows a remarkable similarity to the Heterophyidae with which the worm agrees in having simple sac-like intestinal ceca extending to the posterior end, genital pore in immediate neighborhood of the ventral sucker if that organ is what has been interpreted as the female genital opening by Stafford. Testes oval, symmetrically arranged near the posterior end, seminal vesicle S-shaped, ovary oval, median, anterior to the testes. Vitellaria lateral to the intestinal ceca; extending from the level of the testes. The eggs also fall within the size found in this family but differ in having a short hooked filament at the blunt end. It differs also in that scales have not been recorded for this species by Stafford.

In the above comparison the bulbous vagina of Stafford has been construed to be the ventral sucker and considering this as a sucker this species agrees in every important anatomical feature with the Heterophyidae. The absence of scales here if they have not actually been overlooked could be considered only of specific import and according to the findings of Ward and Hirsh (1915:148) "spines and scales are caducous in life and are easily lost also if the specimens lie in preserving fluid for some time.

The fact that this species was found in the swim bladder of *Amiurus nebulosus* is not sufficient reason for its separation from the Heterophyidae since three genera of that family are known to have larval stages in fish, namely, Metagonimus, Cryptocotyle, and Paracoenogonimus. Ransom (1920:530) surmises that "Heterophyes," the genus to which *Monostomum amiuri* seems to be most closely related, "occur in their immature stages in fish," the adults thus far having been found in fish eating birds and mammals.

Habitat: Swim bladder
Locality: probably near Toronto, Canada
Host: *Amiurus nebulosus*
Collector: Stafford

THE POLYPHYLETIC ORIGIN OF THE MONOSTOMES

From the earliest records of the Monostomata up to the present time this group of parasites has served for a dumping ground for inaccurately studied species in which the acetabulum has been wrongly interpreted or overlooked entirely. Many species have since been studied more carefully and consequently have been transferred to other genera. Out of this has arisen the problem of the origin of the Monostomata. Accumulative evidence has lead to the belief that these forms are directly related to various other groups. This evidence is presented below.

Certain investigators of recent time have come to consider the trematodes of polyphyletic origin. According to Faust (1918) these conclusions are the result of "lack of study and consequent inability to recognize the fundamental resemblance of the genital, excretory and nervous systems."

The first to suggest relationship between the Monostomata and the Distomata was Monticelli (1893:149–150) when he called attention to the similarity of Köllikeria and Didymozoon. More recently Ariola (1906) reinforced this opinion by grouping *Monostoma fillicolle* Rud. and *Distoma okeni* Kölliker together on the basis of their anatomical similarity even though *Monostoma fillicolle* does not possess an acetabulum. MacCallum and MacCallum (1916) on the basis of anatomical similarity grouped together the two genera Köllikeria and Nematobothrium altho Köllikeria shows in many cases well developed acetabula while Nematobothrium is in that respect typically monostomatous.

Cohn (1904) in his study of *Monostomum flavum* Mehlis, worked over by Stossich (1902) and placed in the new genus Typhlocoelum, found a well developed but small ventral acetabulum which he figures in sagittal sections. This species on the one hand is apparently very closely related to the genus Cyclocoelum and was placed by Stossich in the same subfamily, Cyclocoelinae. On the other hand Cohn would transfer this to the Fasciolidae because of the presence of the ventral acetabulum which he says is diminished and in other instances often lost because of the shut-in habitat under which these worms live.

He adds as was stated previously the observation of a rudimentary mouth sucker in *Cyclocoelum mutabile* and in one other species of this group. Here he states that *Cyclocoelum mutabile* does not lack a primary sucker in many cases and like the Cestodarian Amphilina has lost hold-fast organs because of the lack of need for such organs in the cavities of the body of the host in which habitat these worms are wont to live. According

to this author *Cyclocoelum mutabile* and *Typhlocoelum flavum* are very closely related and because of different stimuli in their respective habitats, viz.: alveolar spaces, abdominal cavity and liver, occasionally the intestine for Cyclocoelum, and trachea and bronchi for Typhlocoelum, the acetabulum of Cyclocoelum has been lost while the oral sucker of Typhlocoelum has atrophied.

In his earlier work (1902) Cohn described *Monostomum oculobium* collected from *Vanellus melanogastrus* as having neither oral nor ventral suckers and relates it to *Cyclocoelum mutabile.* Fuhrmann (1904) describes a species, *Bothriogaster variolaris* collected from the intestine of *Rostrhamus sociabilis*, a South American Falconid, which from his figures and description appears to be very similar to *Monostomum oculobium* of Cohn. He states that in regard to the intestinal crura, absence of the oral sucker and the presence of only a pharynx it is like *Cyclocoelum mutabile.* The position of the genital glands is not the same but on the other hand is like those of *Monostomum oculobium* of Cohn. But it differs from *Monostomum oculobium* in that a ventral sucker is present which Fuhrmann believes Cohn had overlooked in his species. Fuhrmann would place *Bothriogaster variolaris* in the sub-family Syncoelinae of the Fasciolidae.

Odhner (1907) supports the view of Cohn and cites a number of instances to demonstrate it. Chief among these are, first, his genus Aporacotyle which is a blood parasite. He says that this suckerless form has its nearest relative in the distome *Hapalotrema constrictum* (Leared), a blood parasite of the sea turtle. Second, those inhabiting the airsacs have developed the hold-fast organs to the least degree. This includes the Cyclocoelidae in which Odhner says all species are without a ventral sucker except for the recent discovery by Cohn of an entirely rudimentary acetabulum in *Typhlocoelum flavum.* He adds that in the Holostomes and Hemistomes ventral suckers have been greatly reduced and in some instances have disappeared entirely. In further support of this view he cites the reduction of the sucker in the male Bilharzia with the complete loss of this organ in *Bilharzia kovalewski*, and notes also the Echinostome like genus Pegosomum which inhabits the gall duct and has lost entirely the oral sucker. Odhner believes that the Monostomata will be finally split up and appended to other trematode groups, i.e., to the Distomes, Amphistomes, Holostomes and perhaps others.

In the light of the foregoing one may well ask, what is a Monostome? The question has been aptly raised as to what characters or combinations of characters afford a reliable and accurate basis for the natural classification of the trematodes. On the basis of the examples given above the presence or absence of an acetabulum can be considered of relatively little importance and if such be the case other factors must be looked for in an attempt to establish a natural system of classification.

In view of the facts stated above the writer believes that an accurate knowledge of the more fundamental systems of organs will reveal group relationships which have heretofore passed unnoticed. In the present systematic groups homology of organs is a factor which has been generally passed over. This can best be demonstrated by a careful study of the developing organs in the early stages of the life history of the individual. Up to this time little has been done on the life histories of the Monostomata. Von Siebold (1835) and Van Beneden (1861) studied the early stages of the parthenogenetic phase. La Valette St. George (1855) described under the name of *Monostomum flavum* a cercaria which he believed to belong to this species. From his descriptions and figures one can see diagnostic points which tend to show that this cercaria belongs to the Notocotylidae on the basis of the well developed oral sucker, the possession of the locomoter pockets described by Looss, Cort, and Faust for Notocotylid species. The fact that La Valette St. George showed the intestine anastomosed posteriorly does not furnish evidence to the contrary since the crura of the Notocotylid approach each other in the posterior end of the worm and this may easily be mistaken for anastomosis or on the other hand the author may have misinterpreted the excretory ducts for the crura of the intestine. The characteristic features are the absence of the pharynx and the presence of the three eyespots which appear to be characteristic of the Notocotylidae. In addition to these Haldemann, Leidy, Cort and Faust have described some six or seven monostome cercaria from American hosts all of which have been referred to the Notocotylidae. While the writer has had opportunity to study immature stages of *Notocotylus urbanensis*, the preserved material has yielded only few facts that can be interpreted as of phylogenetic importance. These will be discussed in a subsequent section of this paper. As yet no Monostome life history has been demonstrated experimentally and the development of the important systems of organs has not been followed in the life history of even a single species. This seems to the writer to be a necessary step to be followed out in the major families in order to demonstrate the phylogenetic relationships of the large groups.

INTERRELATIONSHIP OF THE MONOSTOME FAMILIES

Before entering into the discussion of the probable origin of the Monostomes it seems fitting to discuss the interrelationship of the families as a unit or natural group of Trematodes. A comparison of the family diagnoses, given earlier in this paper, shows a striking contrast in each of the families discussed and of the families not included the same striking contrast may be drawn. No system of organs is the same in all of the families save perhaps the nervous system, so far as it has been made out, which is essentially the same in all the trematodes. The excretory system differs

in these families; in the Cyclocoelidae it is composed primarily of a large half-moon shaped bladder and ramifying network of anastomosed tubules. In the Notocotylidae a single club-shaped bladder extends almost to the ovary and sometimes a little posterior to the excretory pore (*Notocotylus quinqueserialis*); at the anterior end of this bladder two branches are given off which pass lateral to the ovary and from these numerous side branches are produced. In the Heronimidae the bladder consists of a large median sac with the pore in the anterior dorsal region, while in the Collyriclidae the bladder is single, club-shaped, and branches near the center of the body. In regard to the digestive system equally striking differences appear. The Notocotylidae show no trace of a pharynx while the Cyclocoelidae, Heronimidae and the Collyriclidae possess both sucker and pharynx. The crura of the Cyclocoelidae anastomose in the posterior end of the body while in the other families under consideration the crura end blindly. Another characteristic difference is the presence of dermal glands in some of the Notocotylidae, while such organs are unknown in the other families.

In the genital system are to be found equally great characteristic differences in the position of the glands with respect to the intestinal crura as well as in the form of the glands themselves. These and other important differences seem to indicate that these families have arisen from different lines.

THE APPARENT RELATION OF THESE FAMILIES TO OTHER GROUPS

Since the great diversity of structure in this group seems to indicate that the monostomes have arisen from different sources, there remains to be considered in conjunction with this fact the close affinity of certain of these families to widely separated groups.

The finding of a rudimentary acetabulum in *Monostomum flavum* Mehlis by Cohn and of the well developed acetabulum in *Bothriogaster variolaris* by Fuhrmann in the same year together with the similarity in structure seems to indicate a relationship to the Fasciolidae through the Syncoelinae according to Fuhrmann (1904) to which Bothriogaster is most closely related.

After a similar manner the Notocotylidae find their closest parallels among marine forms where the genus Notocotylus has anatomically a very close relative in *Adenogaster serialis* while those Notocotylids without the ventral glands appear more like the genus Glyphicephalus.

The Heronimidae stand alone in their organization and do not show close relationship to any known trematodes.

Attention was first called to the distome character of *Collyriclum faba* by Braun (1892) and again by Kossack (1911:577) who points out the relation of this species to *Distomum gastrophilum* but hesitates to decide whether it is a natural one, thus: "Indessen wage ich es vorläufig noch

nicht zu entscheiden, ob hier natürliche Verwandtschaft oder nur eine Konvergenzerscheinung vorliegt."

More recently Odhner (1914) placed this genus in his new family Troglotremidae which he characterizes as follows: Mehr oder weniger abgeplattete "Distomen" oder "Monostomen" von gedrungener Körperform und 2–13 mm Länge. Das äusserste Hinterende als ein kleiner "Schwanzanhang" vorstreckbar. Bauchfläche flach oder etwas ausgehöhlt, Rückenfläche gewölbt. Haut über und über mit spitzen Stacheln bewaffnet. Muskulatur bei den Cystenbewohnern schwach entwickelt, auch in den Saugnäpfen. Darmapparat mit Pharynx, nicht allzu langem Oesophagus and Darmschenkeln, die ein mehr oder weniger kurzes Stück vor dem Hinterende endigen. Exkretionsblase Y-förmig oder einfach schlauchförmig. Genitalporus dicht am Vorder- oder Hinterrand des ev. Bauchsaugnapfes, median oder leicht lenkseitig. Cirrusbeutel meist fehlend, [except Troglotrema] Pars prostatica und Samenblase immer unterscheidbar. Hoden symmetrisch, in oder hinter der Körpermitte, längs gestellt. Ovar unmittelbar vor den Hoden, rechtseitig, [Except *Paragonimus westermanni* in which amphytypy occurs] meist stark gelappt [except Troglotrema]. Receptaculum seminis und Laurerscher Kanal vorhanden. Dotterstöcke meistens sehr stark entwickelt [except Collyriclum] und dabei ausschliesslich oder hauptsächlich unter der Rückenflächs ausgebreitet, nur einen medianen Streifen frei lassend. Uterus bald sehr lang und stark hin und her gewunden, bald relativ kürzer und mehr aufgeknäuelt. Eier im ersteren Falle klein, 0.017–0.025 mm lang, im letzteren bedeutend grösser, von 0.063–0.085, nach einigen Angaben sogar bis 0.12 (?) mm Länge.—Parasiten von carnivoren Säugetieren oder von Vögeln, meistens paarweise in cystenähnlichen Höhlungen."

This family appears to be an unnatural grouping. Of the four genera included three of them, Troglotrema, Paragonimus and Collyriclum, show radical divergence from the family diagnosis as evidenced by the fact that exceptions must be made in order to include them. In an appendix the author adds to this new family *Renicola pinguis* which he says is the closest relative of *Collyriclum faba*.

Jegen (1917) cites the close relationship of Collyriclum to *Brandesia turgida*. This author emends the family diagnosis of Odhner for the new family Troglotremidae as follows in order to include these two genera, Renicola and Brandesia. "Die Haut entweder mit spitzen Stacheln oder mit Schuppen durchsetzt. Bauchsaugnapf entweder unmittelbar vor oder hinter der Körpermitte."

The present investigations do not show the same close relationship for Collyriclum as found by Odhner and Jegen in the family Troglotremidae while it shows a distinct relationship to Brandesia. This genus is strikingly different from other genera in Odhner's family Troglotremidae.

Table II. Probable Relationships of Collyriclidae

	Brachycoelinae	*Collyriclidae*	*Pleurogenetinae*
Shape	Egg-shaped or spherical	Hemispherical	Small to medium slightly elongated
Integument	Naked rarely spinous	Spinous-in rows	Spiny or scaled
Oral sucker	Well developed	Terminal small	Weakly developed
Acetabulum	Well developed	Wanting	Weakly developed
Pharynx	Small	Smaller than sucker	Poorly developed
Crura	Thin, small	Thin, voluminous	Never reaching posterior end
Excretory	V-shaped	Large Y-shaped	V or Y-shaped
Genital pore	Ventral between suckers	Center of ventral surface	Between suckers, lateral
Copulatory organs	Present or absent	Present, moderately developed	Well developed
Testes	Symmetrical oval	Symmetrical, irregularly lobed	Symmetrical oval
Ovary	Lateral, near acetabulum	Lateral, anterior, deeply lobed	Lateral, near or anterior to acetabulum
Receptaculum seminis	Present	Wanting (?)	Present
Laurer's canal	Present	Present	Present
Vitellaria	Single arborescent group	Several arborescent groups on each side	Simple arborescent group anterior to crura
Uterus	Usually posterior to testes	In general in posterior body half	Usually in posterior body half
Eggs	Numerous about 22μ long	Numerous 19 to 21μ long	29 to 34μ long 13 to16μ broad
Host	Mammals, birds and reptiles	Birds, parasitic in pairs in cysts	Amphibia and reptiles. Renicola and Loxogenes in pairs

The position of the genital pore as well as the organology depicts it as distinct from Collyriclum. This study confirms the systematic position of Brandesia given by Looss in that it is more closely related to the Pleurogenetinae. Collyriclum is in some respects closely related to the Pleurogenetinae and in other respects to the Brachycoelinae. The diagnostic characters of Collyriclum are so evenly distributed between these two subfamilies that it holds an intermediate place as shown in the table opposite.

Whether the interpretation given above is the correct one remains indeed a matter of conjecture and certainly lacks much of confirmation. It is difficult to ascertain from an anatomical study of adult forms as to whether acetabula are vestigial. The most immature Cyclocoelidae studied by the writer show no trace of such organs. These forms belong to *Cyclocoelum obscurum*. In more advanced stages of *Cyclocoelum halli* the sucker is found practically as well developed as in the adult. Since the material of the immature stage of *Cyclocoelum obscurum* was not well preserved conclusions cannot be drawn from it. In the immature stages of *Notocotylus urbanensis* studied by the writer the ventral glands were found to develop after encystment of the cercariae and to show no relation in their development to an acetabulum. Much evidence on this point can yet be obtained by the elucidation of this and other life histories.

It is worthy of note, however, that in the Notocotylidae the oral sucker is well developed in the cercariae as well as in the adult, but instead of a single well developed acetabulum the condition is somewhat varied. In *Notocotylus quinqueserialis* five rows of small sucking discs are provided. In *Notocotylus attenuatum* three rows of similar organs are present, while in Nudocotyle and Paramonostomum no such sucking organs are present. These species live in a similar habitat (intestine of the muskrat) and under this condition have developed in the first instance different numbers of these organs while in the latter case no such structures have been observed. *Nudocotyle novicia*, however, presents other striking differences which need not be considered here. In the cercariae of these forms described notably by Cort (1914) and Faust (1918) no such organs are found nor is there any indication of their early development, while in the immature forms of *Notocotylus urbanensis* studied by the writer these glands are found well along in development soon after being freed from the cyst. The other organs of these cercariae correspond so well to the adult structure that there is little doubt as to the identity of the form. In this case then the sucking discs are developed after the organism enters the definitive host. A final decision of this question, however, must await further evidence and experimental demonstration of the life history.

The cases of reduction of sucking musculature cited by Cohn (1904) and Odhner (1907, 1911) lead again to the question raised previously and in the light of the theory of Cohn and Odhner it is difficult to determine

if this reduction is of phylogenetic import or subject to rapid change under environmental stimuli. A comparison of similar worms under different conditions leads to the belief that the sucking musculature is not subject to such rapid and radical change as indicated by Odhner (1907). As shown in an earlier part of this paper, *Cyclocoelum wilsoni* and *Cyclocoelum vicarium* from the intestine of their host have poorly developed oral suckers and no trace of an acetabulum while Cohn has found a rudimentary acetabulum in *Monostomum flavum*, a species which inhabits the trachea.

In the Heronimidae which inhabit the lungs and especially the larger bronchi of turtles, the oral acetabulum is well developed while any evidence of the presence of a ventral sucker has not been obtained. This stands in rather striking contrast to the statement of Odhner (1907) referred to above. Fuhrmann (1904) cites an interesting case in his *Bothriogaster variolaris* which was collected from the intestine of *Rostrhamus sociabilis*. This species according to the author has a ventral acetabulum but no oral sucker. A pharynx, however, is present. As stated previously his species is strikingly similar to *Monostomum oculobium* Cohn taken from *Vanellus melanogastrus* which Cohn (1902) says is devoid of sucking apparatus. Why has the oral sucker of *Bothriogaster variolaris* atrophied if reduction is due to habitat as stated by Cohn (1902) and Odhner (1907)?

Another interesting correlation is found among the Notocotylidae and the Pronocephalidae both of which inhabit the intestine. Among the Notocotylidae are forms which late in life develop the ventral holdfast or adhesive glands and those without such glands, both types of which have been found in the alimentary tract of the muskrat. Linton (1910) reports a species *Barisomum erubescens* from the intestine of three tropical fish which show no sign of any sucking organ save the oral. Of the several genera of the Pronocephalidae taken from the intestine of *Chelone midas* only Adenogaster shows any trace of accessory adhesive apparatus. On the other hand Odhner (1911) found reason to ally the Angiodictyidae a closely related family to the distomes on account of a weakly developed acetabulum found in *Haplorchis carhinus* Looss.

As was stated previously Odhner (1907) proved beyond doubt the presence of both pharynx and oral sucker in *Didymozoon scombri* Tschbg. but found there no ventral sucker. Four years later Ariola (1906) asserts the Didymozoon nature of *Köllikeria* (Distoma) *okeni* (Kölliker) which he states is synonymous with *Monostomum fillicolle* Rud. In the Parona material reported as Köllikeria in which there were many distomes according to this author, he finds a single form without the acetabulum.

On the other hand *Collyriclum faba* (Bremser) and *Collyriclum colei* Ward, other cyst living trematodes, have no acetabula but present, however, a well developed oral sucker. It is difficult to interpret how worms which

live under such similar conditions as the Didymozoonidae and the Collyriclidae could by the effect of habitat alone become so totally different.

That the habitat in which the worm lives is a factor in the modification cannot be disputed but is certainly only one factor which contributes to the modification. What makes up the aggregate of factors in a given case could be only a matter of conjecture. Recent experimental investigation, however, has shown that factors influencing modifications of an individual or race may be both external and internal and that the change produced may be gradual or occur as a mutation in which case little or no trace may be left to depict the ancestral route. While the writer is inclined to look upon the loss of sucking musculature as a gradual change brought about by a group of factors among which the habitat seems to have played an important part, there is every reason to believe that sudden radical rearrangements have taken place and these are no doubt responsible for many of the variant forms. While there is good reason to believe that the Monostomata have arisen from highly divergent groups the evidence seems as yet about equally divided and the final decision must necessarily rest on further studies of the anatomy and life history of members of this and other groups.

The systematic arrangement used in the earlier part of this paper is essentially that employed by Lühe (1909), Kossack (1911) and Ward (1918), which for the above stated reason it seemed best to preserve at least for the present. It is hoped that interest in this aberrant group will increase and that careful studies will result either in the preservation of these forms as a natural taxonomic group or in their separation and subsequent distribution among other well organized units to which they are truly related.

SUMMARY

I. Monostomes from North American land and fresh water hosts have been studied.

II. Nine new species have been described in detail.

III. The knowledge of their anatomy and life history is greatly increased.

1. Both oral sucker and pharynx are present in the Cyclocoelidae.
2. In the genera of Cyclocoelidae studied the receptaculum seminis is a constant feature while Laurer's canal is not present.
3. The origin of the ventral glands in *Notocotylus urbanensis* is clearly shown in early stages of development.

IV. The discovery of well developed miracidia in *Collyriclum colei* renders improbable Jegen's account of the life history of *Collyriclum faba*.

V. A careful study of the anatomy of the Cyclocoelidae, the Notocotylidae, the Collyriclidae, and the Heronimidae demonstrates clearly that they are not immediately related.

1. The Cyclocoelidae are probably allied to the Fasciolidae.
2. The Notocotylidae are closely related to the Pronocephalidae not merely in general organology but especially in the presence of peculiar ventral glands.
3. A study of the organology of the Collyriclidae demonstrates clearly their direct relationship to the Pleurogenetinae.
4. The Heronimidae do not show immediate relationship to any known trematodes.

VI. The monostomes are a heterogeneous group and must ultimately be distributed among other groups in accordance with their fundamental relationships.

BIBLIOGRAPHY

ARIOLA, V.

1906. *Mayostoma filicolle* Rud. e *Distoma okeni* Kölliker. Zool. Anz., 30:185–186.

ARNSDORFF, A.

1908. *Monostomum vicarium*. Centralbl. Bakt. Par., Abt. I, Orig., 47:362–366; 2 fig.

BAIRD, W.

1853. Catalogue of the species of entozoa or intestinal worms contained in the collection of the British Museum. London; 2 pl.

BARKER, F. D.

1915. Parasites of the American Muskrat (*Fiber zibethicus*). Jour. Par., 1:184–197; 2 pl., 4 figs.

1916. A new Monostome Trematode Parasitic in the Muskrat with a Key to the Parasites of the American Muskrat. Trans. Amer. Mic. Soc., 35:175–184; 1 pl.

BARKER, F. D. and LAUGHLIN, J. W.

1911. A New Species of Trematode from the Muskrat, *Fiber zibethicus*. Trans. Amer. Mic. Soc., 30:261–274; 1 pl.

BARKER, F. D. and PARSONS, SUSANNE.

1914. A new species of Monostome from the Painted Terrapin, *Chrysemys marginata*. Zool. Anz., 45:193–194.

1917. A Monostome Lung Fluke from the Painted Terrapin, *Chrysemys marginata* Agassiz. Trans. Amer. Mic. Soc., 36:55–66; 2 pl.

VAN BENEDEN, P. J.

1861. Mémoire sur les vers intestinaux. Suppl. C. r. Acad. Sci., 2:1–376.

BLANCHARD, R.

1903. Experiences et observations sur la marmotte en hibernation. VI. Observations sur les parasites en general. C. r. Soc. biol., 55:1124–26.

BLOCH, M. E.

1782. Abhandlung von der Erzeugung der Eingeweidewürmer. Berlin. 54 pp.; 10 pl.

BLOCHMANN, F.

1896. Die Epithelialfrage bei Cestoden und Trematoden. Hamburg. 12 pp.; 2 pl., 1 fig.

BRANDES, G.

1891. Zum feineren Bau der Trematoden. Zeit. wiss. Zool., 53:558–577; 1 pl.

1892. Revision der Monostomiden. Centrlbl. Bakt. Par., 12:504–511.

BRAUN, M.

1889–1893. Trematodes, in Bronn's Klass. Ordn. d. Thier-Reichs. 4, Abt. 1a:306–925.

1893. II. Bericht über thierische Parasiten. Centrlbl. Bakt. Par., 13:59–68.

1893a. Die Wohnsitze der endoparasitischen Trematoden. Centrlbl. Bakt. Par., 13: 465–468.

1901. Trematoden der Chelonier. Mitt. zool. Mus. Berlin, 2, 58 pp.; 2 pl., 2 fig.

1901a. Zur Kenntniss der Trematoden der Säugethiere. Zool. Jahrb., Syst., 14:311–348; 2 pl.

BREMSER, M.

1831. Schmalz, XIX Tabulae Anatomian entozoorum illustrantes. Dresdae et P Lipsiae; 11–16. (Not available.)

COBBOLD, T. S.

1860. Synopsis of the Distomidae. Jour. Proc. Linn. Soc. Lond. Zool., 5:1–56.

1864. Entozoa; An introduction to the study of Helminthology. London. 480 pp.; 21 pl., 82 text fig.

COHN, L.

1902. Mittheilungen über Trematoden. Zool. Anz., 25:712–718; 9 fig.

1904. Helminthologische Mitteilungen II. Arch. Naturg., 1:229–251.

COLE, L. J.

1911. A Trematode Parasite of the English Sparrow in the U. S. Bull. Wisc. Nat. Hist. Soc., 9:42–48; 2 pl.

CORT, W. W.

1913. Notes on the Trematode Genus Clinostomum. Trans. Amer. Mic. Soc., 32: 169–182; 1 pl.

1914. Larval Trematodes from North American Fresh-Water Snails. Jour. Par., 1:65–84; 15 figs.

1915. Some North American Larval Trematodes. Ill. Biol. Monogr., 1:446–532; 8 pl.

CREPLIN, F. C. H.

1829. Filariae et Monostomi speciem novam in *Balaena rosirata* repertam. Nova acta Phys.-med. Acad. Nat. curios., Bonnae, 14:871–882; 1 pl.

DIESING, K. M.

1839. Neue Gattungen von Binnenwürmern. Ann. Wien. Mus. Naturg., 2:219–242; 7 pl.

1850. Systema Helminthum. Vienna; 1, 679 pp.

1858. Revision der Myzhelminthen: Trematoden. Sitz. Akad. Wiss. Wien, math.-naturw. Cl., 32:207–390; 2 pl..

1859. Nachträge u. Verbesserungen zur Revision der Myzhelminthen. Sitz. Akad. Wiss. Wien, math-naturw. Cl., 35:421–451.

DUJARDIN, F.

1845. Histoire naturelle des helminthes ou vers intestinaux. Paris. 654 pp.

FAUST, E. C.

1918. Life History Studies on Montana Trematodes. Ill. Biol. Monogr., 4:1–120; 9 pl.

FILIPPI, F. DE

1856. Quelques nouvelles observations sur les larves des trématodes. Ann. sci. nat., Zool., (4) 6:83–86. [Translation, Ann. Mag. Nat. Hist., (2) 20:129–132.]

1859. Troisiéme mémoire pour servir à l'histoire génétique des trématodes. Mem. Accad. sci. Torino, (2) 18:201–232; 3 pl.

FRÖLICH, J. A. VON.

1789. Beschreibung einiger neuen Eingeweidewürmer. Naturforscher., Halle, 24:101–162; 4 pl.

FUHRMANN, O.

1904. Neue Trematoden. Centrlbl. Bakt. Par., Abt. I, Orig., 37:58–64; 4 fig.

GMELIN, J. F.

1790. Caroli a Linné Systema Naturae, Vermes. 13 ed., 1:3021–3909.

GOEZE, J. A. E.

1782. Versuch einer Naturgeschichte der Eingeweidewürmer thierischer Körper. Blankenburg. 471 pp.; 44 pl.

HARRAH, E. C.

1921. Two new Monostomes from Asia. Jour. Par., 7:162–165; 2 fig.

HOYLE, W. E.

1888. Trematoda. Encycl. Brit., N. Y. 9 Ed., 23:535–540.

JÄGERSKIÖLD, L. A.

1891. Über den Bau des *Ogmogaster plicatus* (Creplin) (*Monostomum plicatum* Creplin) K. Svensk. Vetensk.-Acad. Handl., Stockholm, 24:1–32; 2 pl.

JEGEN, G.
1917. *Collyriclum faba* (Bremser) Kossack. Ein Parasit der Singvögel, sein Bau und seine Lebensgeschichte. Zeit. wiss. Zool., 117:460–553; 2 pl.

JOHNSTON, S. J.
1916. On the Trematodes of Australian Birds. Jour. Proc. Roy. Soc. N. S. W., 50: 187–261; 11 pl.

KOSSACK, W.
1910. Neue Distomen. Centrlbl. Bakt. Par., Abt. I, Orig., 56:114–120; 4 fig.
1911. Über Monostomiden, Zool. Jahrb., Syst., 31:493–590; 3 pl.

LAHILLE, F.
1918. Nota sobre *Monostoma mutabile* y la clasificacion general de los Trematodes. Buenos Aires. Physis: Rev. Soc. Arg. Ci. Nat., 4:328–331.

LANG, A.
1880. Untersuchungen zur vergleichenden Anatomie und Histologie des Nervensystems der Platyhelminthen. II. Über das Nervensystem der Trematoden. Mitt. Zool. Stat. Neapel, 2:28–52; 3 pl.

LA VALETTE ST. GEORGE, A. J. H. VON
1855. Symbolae ad trematodum evolutionis historiam. Berolini, 39 pp.; 2 pl.

LEIDY, JOS.
1856. A Synopsis of Entozoa and some of their Ectocongeners observed by the author. Proc. Acad. Nat. Sci. Phila., 8:42–58.
1858. Contributions to Helminthology. Proc. Acad. Nat. Sci. Phila., 10:110–112.
1877. On Flukes infesting Molluscs. Proc. Acad. Nat. Sci. Phila., 29:200–202.
1884. Distoma and Filariae. Proc. Acad. Nat. Sci. Phila., 36:47–48.
1885. On some parasitic worms of birds. Proc. Acad. Nat. Sci. Phila., 37:9–11.
1887. Notice of some parasitic worms. Proc. Acad. Nat. Sci. Phila., 39:20–24.
1890. Notices of Entozoa. Proc. Acad. Nat. Sci. Phila., 42:410–418.
1904. Researches in helminthology and parasitology. Smithson. Misc. Coll., 46:1–281. [Leidy, 1904, is an exact reprint of all his original papers.]

LINTON, EDWARD.
1910. Helminth Fauna of the Dry Tortugas. II. Trematodes. Carnegie Inst. Pub., 133:11-98; 28 pl.

LÖNNBERG, E.
1891. Mitteilungen über einige Helminthen aus dem zool. Museum der Universität zu Kristiania. Verh. biol. Ver. Stockholm, 3:64–78; 1 pl.

LOOSS, A.
1899. Weitere Beiträge zur Kenntniss der Trematoden-Fauna Aegyptens, zugleich Versuch einer natürlichen Gliederung des Genus Distomum Retzius. Zool. Jahrb., Syst., 12:521–784; 9 pl.
1901. Natura doceri, eine Erklärung und Begründung einiger Grundsätze, welche mich bei meinem "Versuch einer natürlichen Gleiderung des Genus Distomum Retzius" geleitet. Centrlbl. Bakt. Par., Abt. I, 29:191–210.
1902. Über neue und bekannte Trematoden aus Seeschildkröten. Zool. Jahrb., Syst., 16:411–894; 12 pl.

LÜHE, M.
1900. [Review of] Looss, A., Weitere Beiträge etc. Centrlbl. Bakt. Par., Abt. 1, 28:458–466.
1901. Über *Monostomum orbiculare*. Centrlbl. Bakt. Par., Abt. 1, 29:49–60; 5 fig.
1901a. Zwei neue Distomen aus indischen Anuren. Centrlbl. Bakt. Par., Abt. 1, 30:166–177; 5 fig.

1909. Parasitische Plattwürmer. Brauer, Die Süsswasserfauna Deutschlands, 17, 217 pp.; 188 fig.

MacCallum G. A. and MacCallum, W. G.

1916. The family Koellikeriadae (Didymozoidae) Mont. Zool. Jahrb., Syst., 39:141–168; 3 pl.

MacCallum, W. G.

1902. *Heronimus chelydrae*, nov. gen., nov. sp. A new Monostome parasite of the American snapping turtle. Centrlbl. Bakt. Par., Abt. I, Orig., 32:632–636; 2 fig.

Monticelli, F. S.

1888. Saggio di una morfologia dei trematodi. Tesi per ottenere la privata docenza in zoologia nella R. Universita di Napoli. 130 pp.

1892. Studii sui trematodi endoparassiti. Dei Monostomum del Box salpa. Atti. Accad. sci. Torino, 27:514–534; 1 pl.

1892a. Studii sui trematodi endoparassiti. *Monostomum cymbium* Diesing. Mem. Accad. sci. Torino, 42:683–727; 1 pl.

1892b. Studii sui trematodi endoparassiti; sul genere Notocotyle Diesing. Boll. Soc. nat. Napoli, 6:28–46.

1893. Studii sui Trematodi endoparassiti. Primo contributo di osservazioni sui Distomidi. Zool. Jahrb., Suppl. 3; 229 pp.; 8 pl., 3 fig.

Odhner, T.

1900. *Aporocotyle simplex* n.g.n. sp., ein neuer Typus von ektoparasitischen Trematoden. Centrlbl. Bakt. Par., Abt. 1, 27:62–66; 1 fig.

1905. Die Trematoden des arktischen Gebietes. Fauna Arctica, 4:291–372; 3 pl., 4 fig.

1907. Zur Anatomie der Didymozoen; ein getrenntgeschlechtlicher Trematode mit rudimentärem Hermaphroditismus. Zool. Stud. Tullberg, p. 309–342; 1 pl., 6 fig.

1911. Zum naturlichen System der digenen Trematoden. I. Zool. Anz., 37:181–191.

1914. Die Verwandtschaftsbeziehungen der Trematodengattung Paragonimus Brn. Zool. Beitr. aus Uppsala, 3:231–245; 5 fig.

Osborn, H. L.

1911. On the Distribution and Mode of Occurrence in the United States and Canada of *Clinostomum marginatum*, a Trematode Parasitic in Fish, Frogs, and Birds. Biol. Bull., 20:350–366; 1 pl.

Pratt, H. S.

1902. Synopses of North American invertebrates. 12. The trematodes. Am. Nat., 36:887–910, 953–979.

Ranson, B. H.

1920. Synopsis of the Trematode family Heterophyidae with descriptions of a new genus and five new species. Proc. U. S. Nat. Mus., 57:527–573; 33 fig.

Rudolphi, C. A.

1801. Beobachtungen über die Eingeweidewürmer. Arch. Zool. Zoot., 2:1–65.

1809. Entozoorum sive vermium intestinalium historia naturalis. 2, 457 pp.

1819. Entozoorum synopsis cui accedunt mantissa duplex et indices locupletissimi. 811 pp.

Schrank, F. von P.

1788. Verzeichniss der bisher hinlänglich bekannten Eingeweidewürmer, nebst einer Abhandlung über ihre Anverwandtschaften. München, 166 pp.

Siebold, C. T. E. von

1835. Helminthologische Beiträge. Archiv Naturg., 1:45–84; 1 pl.

Skrjabin, K. I.

1913. Vogeltrematoden aus Russich Turkestan. Zool. Jahrb., Syst., 35:351–388; 2 pl.

1913a. *Tracheophilus sisowi* n.g. n. sp. Centrlbl. Bakt. Par., Abt. I, Orig., 69:90–94; 1 pl.

STAFFORD, J.
1900. Some undescribed Trematodes. Zool. Jahrb., Syst., 13:399–414; 1 pl.
1902. *Cephalogonimus americanus* (new species). Centrlbl. Bakt. Par., Abt. I, Orig., 32:719–725; 1 pl.

STILES, C. W. and HASSALL, A.
1894. A preliminary catalogue of the parasites contained in the collections of the United States Bureau of Animal Industry, United States Army Medical Museum, Biological Department of the University of Pennsylvania (Coll. Leidy) and in Coll. Stiles and Coll. Hassall. Vet. Mag., 1:245–253, 331–354.
1908. Index-Catalogue of Medical and Veterinary Zoology; Subjects Trematoda and Trematode diseases. Hygienic Lab., Bull. 37:401.

STOSSICH, M.
1902. Il *Monostomum mutabile* Zeder e le sue forme affine. Boll. Soc. adriat. sci. nat. Trieste, 21:1–40; 9 pl.

STUNKARD, H. W.
1917. Studies on North American Polystomidae, Aspidogastridae, and Paramphistomidae. Ill. Biol. Monogr., 3–281–394; 11 pl.
1919. On the specific Identity of *Heronimus chelydrae* MacCallum and *Aorchis extensus* Barker and Parsons. Jour. Par., 6:11–18; 2 pl.

TASCHENBERG, O.
1879. Didymozoon, eine neue Gattung in Cysten lebender Trematoden. Ztschr. ges. Naturw., 5:605–617.

TYZZER, E. E.
1918. A monostome of the genus Collyriclum occuring in the European sparrow, with observations on the development of the ovum. Jour. Med. Res., 38:267–292; 4 pl.

VAILLANT, L.
1863. Note sur deux helminthes trématodes observés chez la sirène lacertine. C. r. Soc. biol., 4:6–7.
1863a. Note sur quelques helminthes de la sirène lacertine. Ann. sci. nat., Zool., 19: 347–350, 1 pl.

WARD, H. B.
1909. The Influence of Hibernation and Migration on Animal Parasites. Proc. 7. Internat. Zool. Cong., 12 pp.
1917. On the Structure and Classification of North American parasitic Worms. Jour. Par., 4:1–12; 1 pl.
1918. Parasitic Flatworms. In Ward and Whipple, Fresh Water Biology. Pp. 365–453; 114 fig.
1921. A New Blood Fluke from Turtles. Jour. Par., 7:114–129; 1 pl.

WARD, H. B. and HIRSH, E. F.
1915. The species of Paragonimus and their differentiation. Ann. Trop. Med. Par., 9:109–162; 5 pl.

WEDL, C.
1857. Anatomische Beobachtungen über Trematoden. Sitz. Akad. wiss. Wien., math.-naturw. Cl., 26:241–278; 4 pl.

WILLEMOES-SUHM, R. VON
1873. Helminthologische Notizen III. (II Über den Bau und den Embryo des *Monostomum faba* Brs.) Zeit. wiss. Zool., 23:332–335; 1 fig.

ZEDER, J. G. H.
1800. Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer, mit Zufässen und Anmerkungen herausgegeben. Leipzig. 320 pp.
1803. Anleitung zur Naturgeschichte der Eingeweidewürmer. Bamberg. 432 pp.

DESCRIPTION OF PLATES

LIST OF ABBREVIATIONS

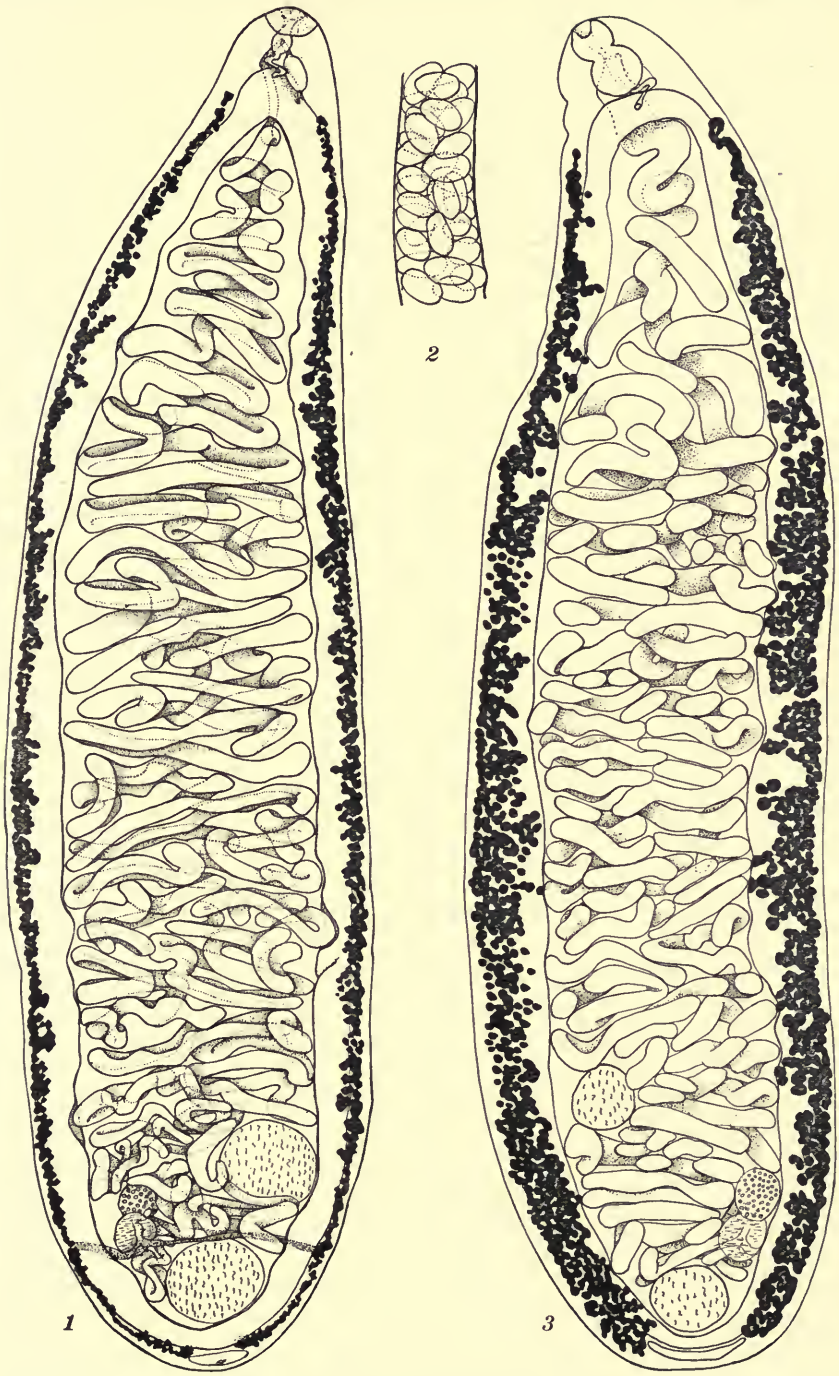
c cirrus
cm circular muscle
cp cirrus pouch
g ventral glands
ga genital atrium
i intestinal crura
lm longitudinal muscle
m mouth
o ootype
e esophagus
om oblique muscle
os oral sucker
ov ovary
p pharynx
pp prepharynx
rs receptaculum seminalis
ru receptaculum seminalis uterinum
sg shell gland
u uterus
v vas deferens
vd vitelline duct
vr vitelline reservoir
w wall of excretory tubule

All drawings were made by the aid of either a camera lucida or an Edinger drawing apparatus.

PLATE I

PLATE I

Fig. 1. *Cyclocoelum leidyi*, dorsal view. ×12.
Fig. 2. Portion of the egg filled uterus of *Cyclocoelum leidyi*. ×45.
Fig. 3. *Cyclocoelum mutabile* (Zeder). Specimen No. 284 from Mehlis Collection, dorsal view. ×12.

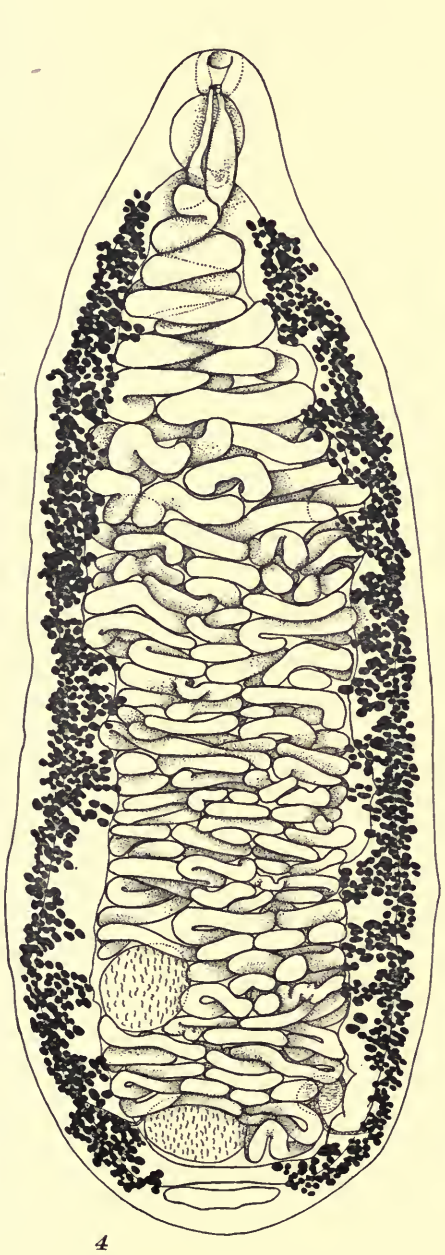


HARRAH NORTH AMERICAN MONOSTOMES PLATE I

PLATE II

PLATE II

Fig. 4. *Cyclocoelum pseudomicrostomum*, ventral view. ×12.
Fig. 5. *Cyclocoelum halli*, ventral view. ×12.



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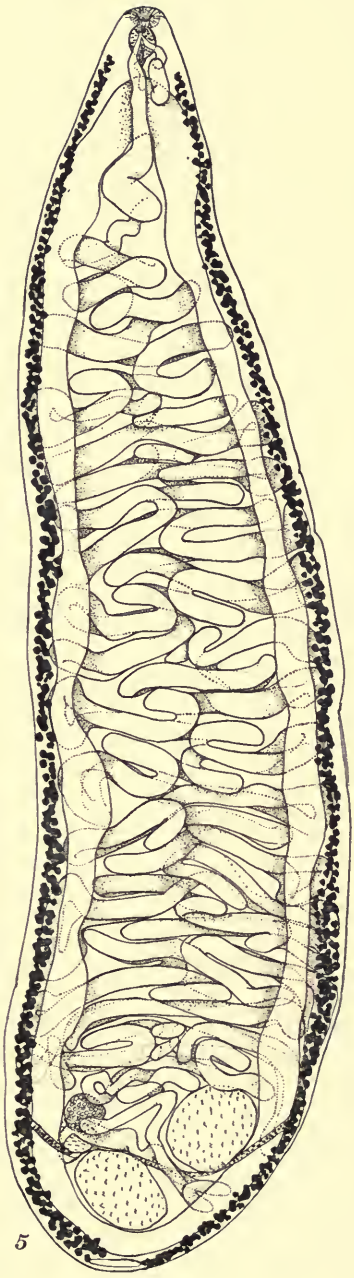

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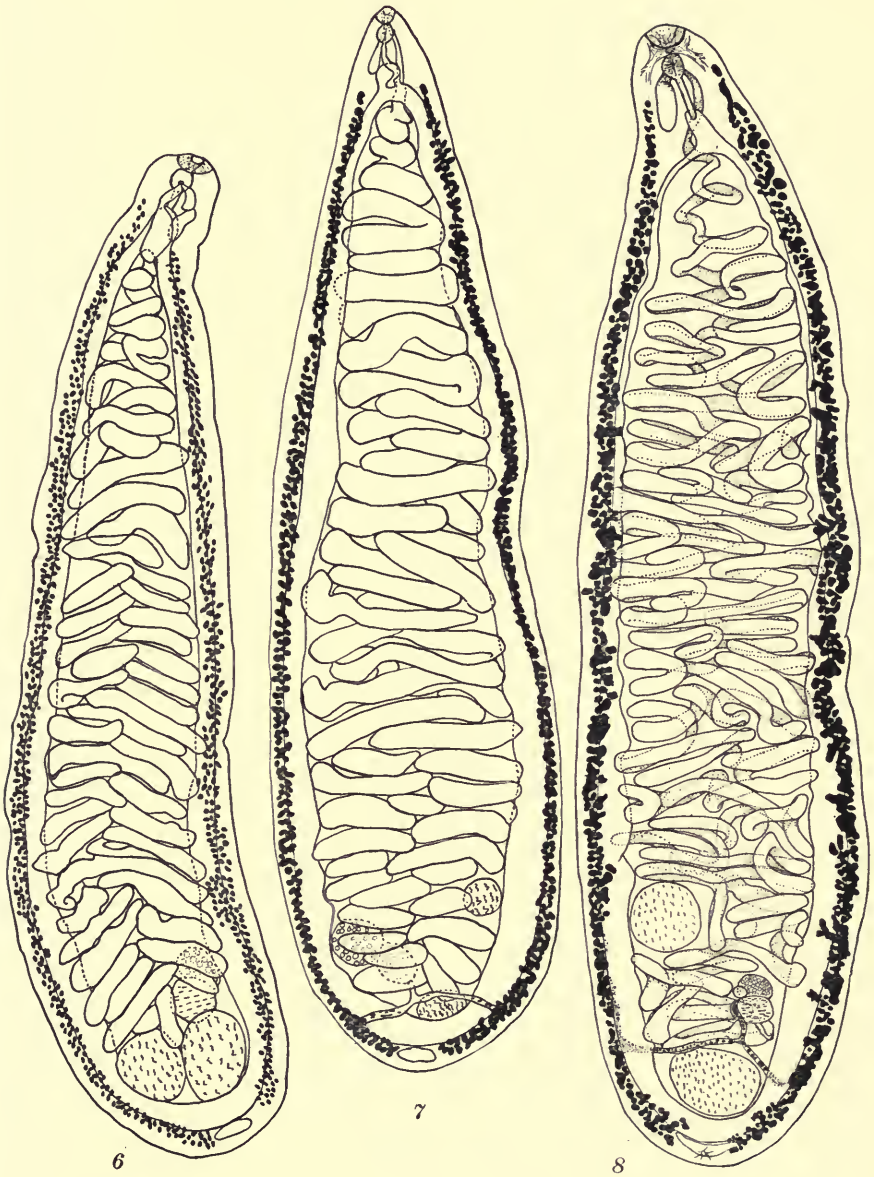
HARRAH NORTH AMERICAN MONOSTOMES PLATE II

PLATE III

PLATE III

Fig. 6. *Cyclocoelum wilsoni*, ventral view. ×12.
Fig. 7. *Cyclocoelum cuneatum*, dorsal view. ×12.
Fig. 8. *Cyclocoelum obscurum*, ventral view. ×17.



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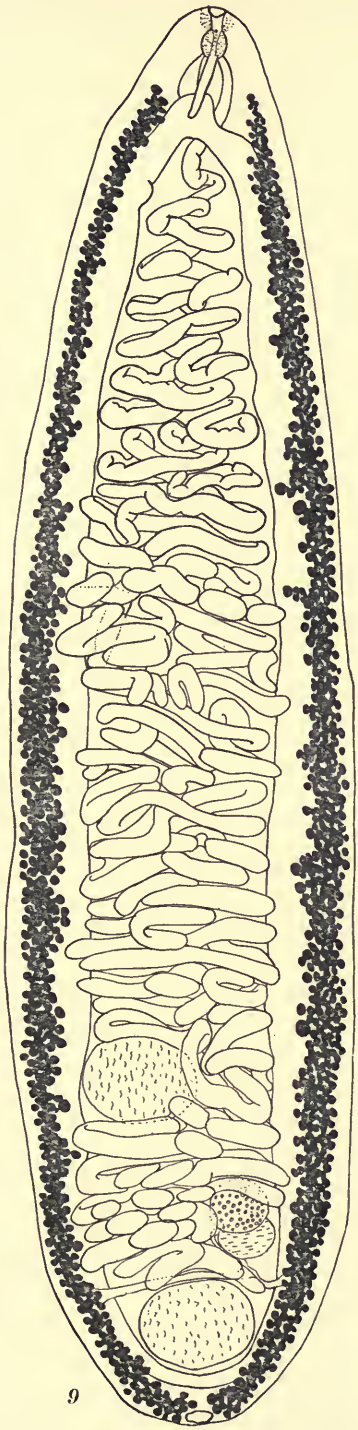
HARRAH NORTH AMERICAN MONOSTOMES PLATE III

PLATE IV

PLATE IV

Fig. 9. *Cyclocoelum macrorchis*, ventral view. ×15.
Fig. 10. *Cyclocoelum triangularum*, ventral view. ×12.
Fig. 11. *Cyclocoelum halli*, young specimen, ventral view. ×23.



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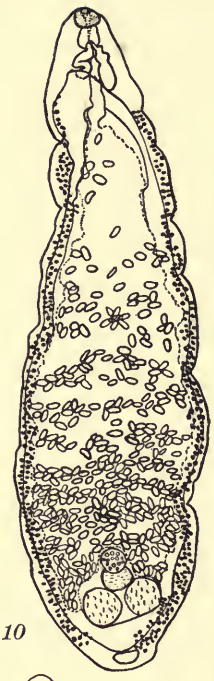

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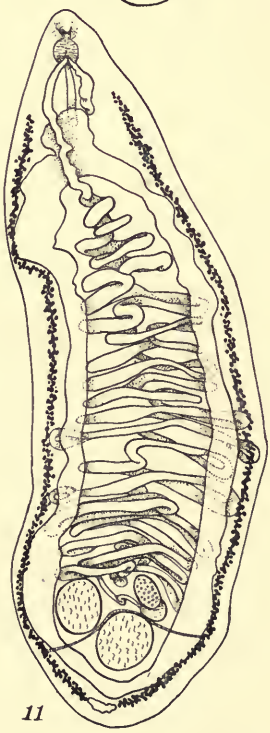

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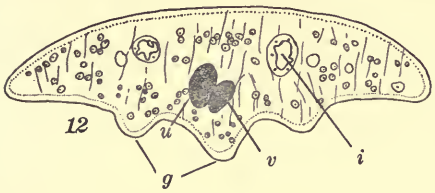
HARRAH NORTH AMERICAN MONOSTOMES PLATE IV

PLATE V

PLATE V

Fig. 12. Cross section, immature specimen of *Notocotylus urbanensis*. ×190.
Fig. 13. Spines of *Paramonostomum echinum*, front view. × 700.
Fig. 14. *Notocotylus urbanensis*, young specimen, partial lateral view. ×95.
Fig. 15. *Paramonostomum echinum*, ventral view. × 87.
Fig. 16. Spines of *Paramonostomum echinum*, lateral view. ×700.
Fig. 17. *Notocotylus urbanensis*, immature stage, ventral view. ×150.
Fig. 18. *Notocotylus urbanensis*, ventral view. ×44.
Fig. 19. *Notocotylus urbanensis*, young specimen, dorsal view. ×120.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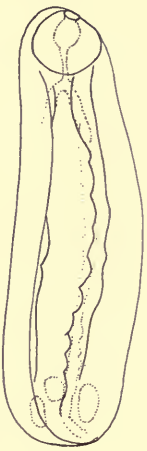
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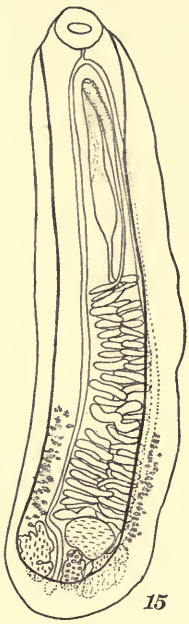
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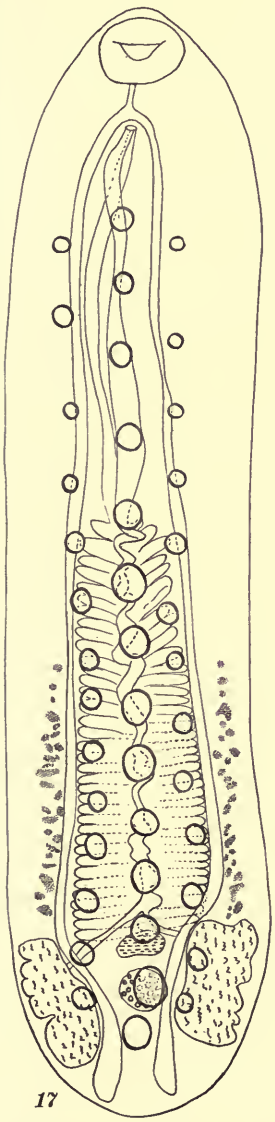
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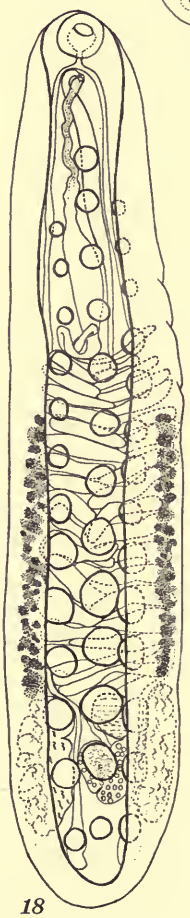
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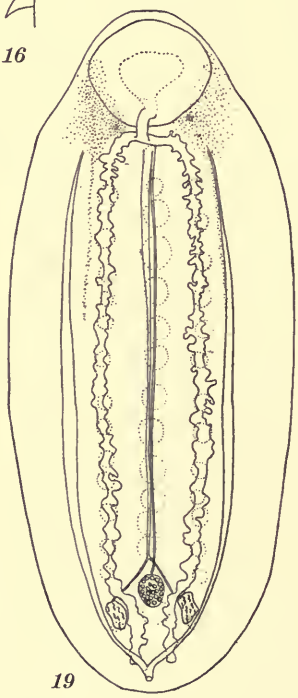
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PLATE VI

PLATE VI

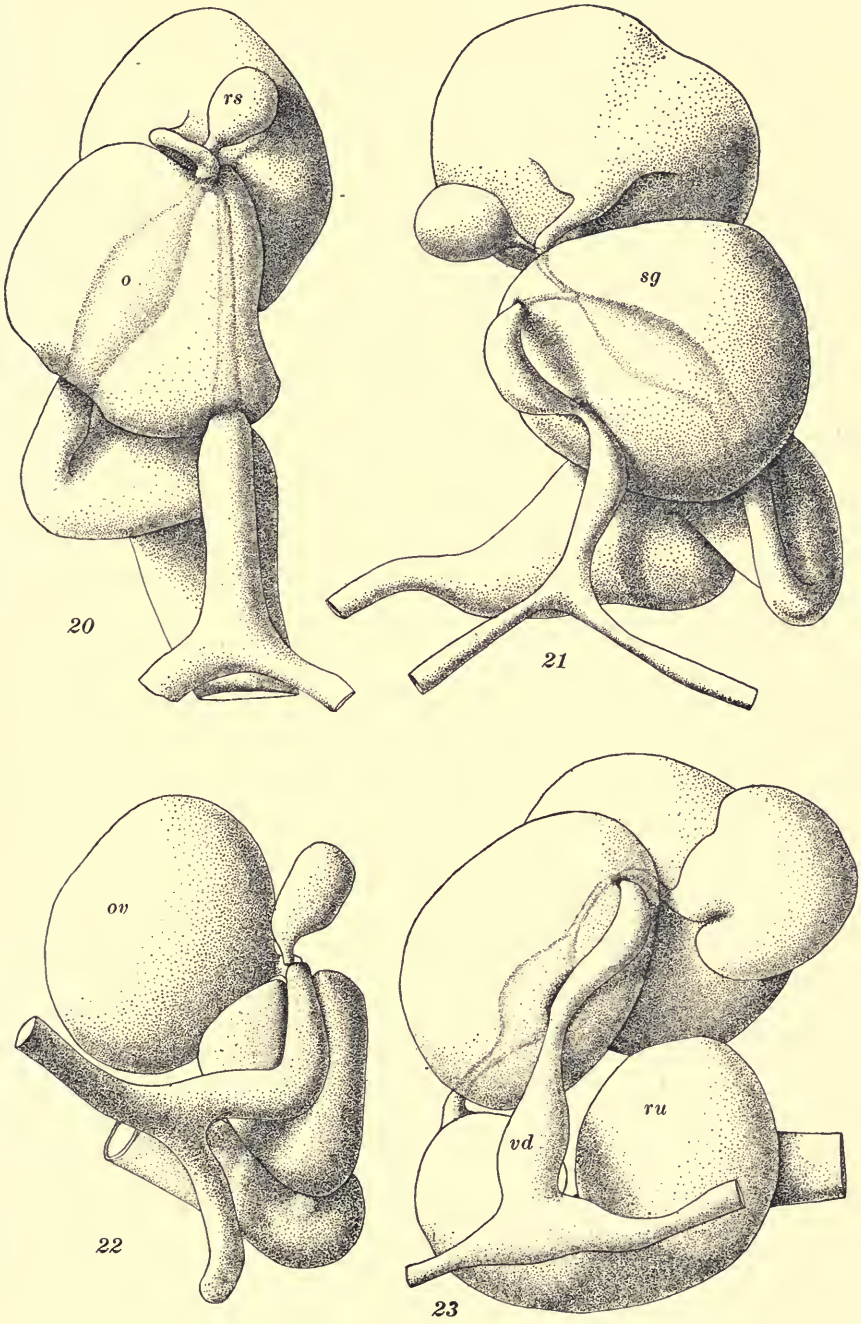
All figures magnified 92 times

Fig. 20. Ovarian complex, *Cyclocoelum halli*, drawing from wax reconstruction.

Fig. 21. Ovarian complex, *Cyclocoelum obscurum*, drawing from toto, same specimen as in figure 8.

Fig. 22. Ovarian complex *Cyclocoelum obliquum*, drawing from wax reconstruction.

Fig. 23. Ovarian complex, *Cyclocoelum problematicum*, drawing from toto mount of No. 2449 Berlin Museum.

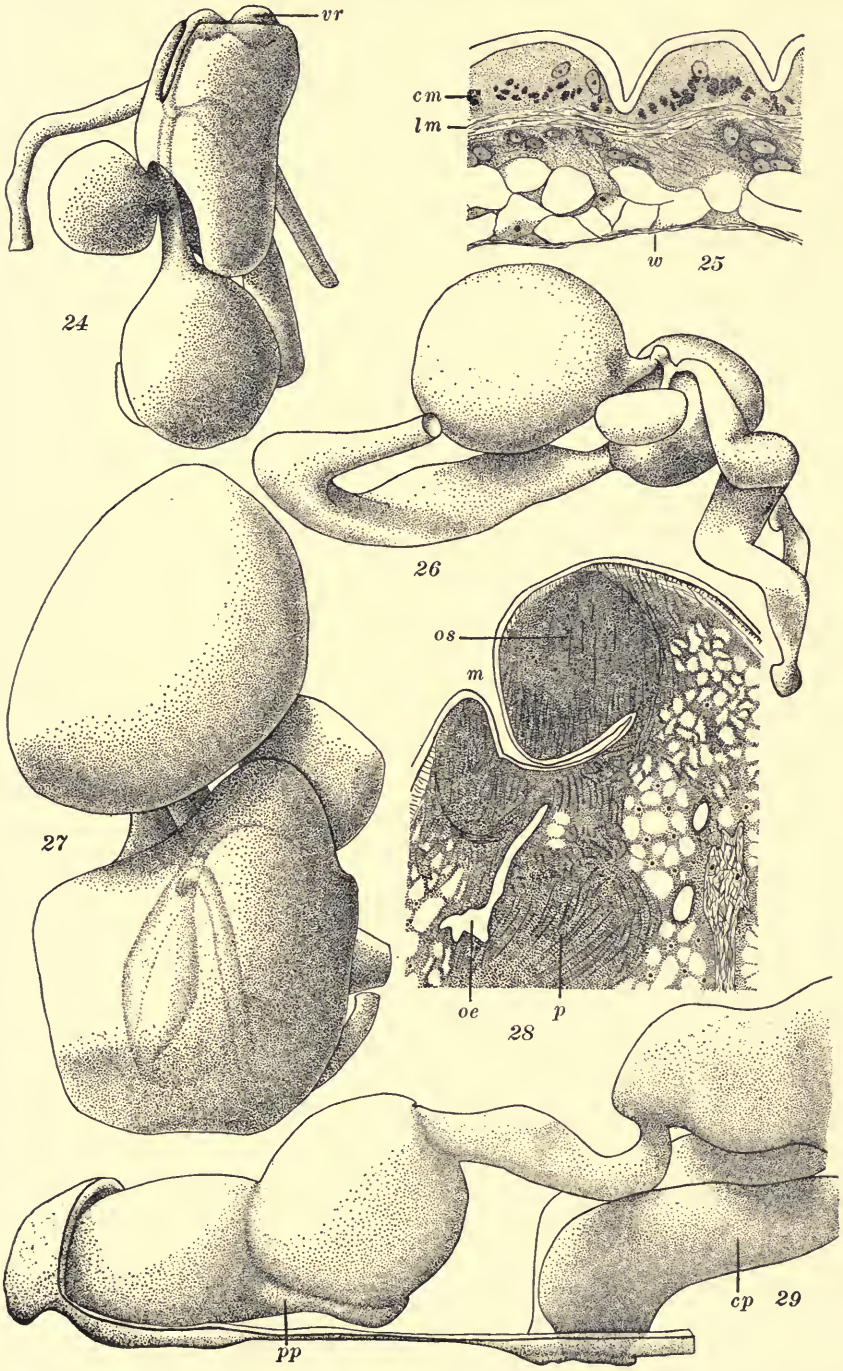


HARRAH NORTH AMERICAN MONOSTOMES PLATE VI

PLATE VII

PLATE VII

Fig. 24. Ovarian complex, *Cyclocoelum cuneatum*, anterior view. ×92.
Fig. 25. Frontal section, showing structure of body wall. × 435.
Fig. 26. Ovarian complex, *Haematotrephus similis*, partial anterior view from above. ×92.
Fig. 27. Ovarian complex, *Cyclocoelum pseudomicrostomum*, dorsal view. ×92.
Fig. 28. Frontal section, anterior end of *Haematotrephus similis*. ×145.
Fig. 29. Drawing of wax reconstruction of anterior end of *Cyclocoelum elongatum*. ×108.



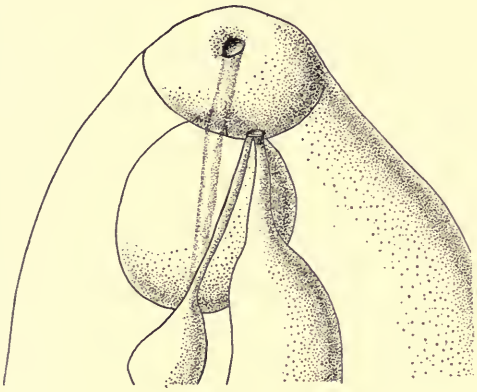
HARRAH NORTH AMERICAN MONOSTOMES PLATE VII

PLATE VIII

PLATE VIII

All figures magnified 44 times

Fig. 30. Ventral view of anterior end of *Cyclocoelum pseudomicrostomum*.
Fig. 31. Ventral view of anterior end of *Cyclocoelum brazilianum*.
Fig. 32. Dorsal view of anterior end of *Cyclocoelum mutabile*.
Fig. 33. Ventral view of anterior end of *Cyclocoelum leidyi*.
Fig. 34. Ventral view of anterior end of *Cyclocoelum elongatum*.
Fig. 35. Ventral view of anterior end, of *Cyclocoelum brazilianum*, cirrus extruded.



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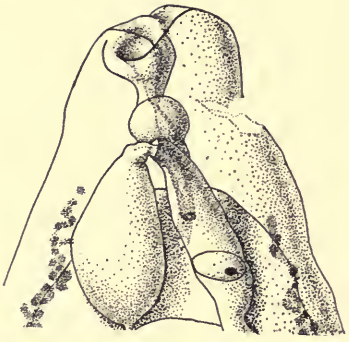

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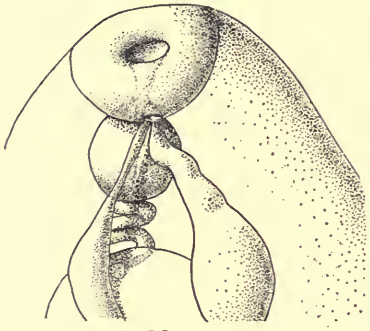

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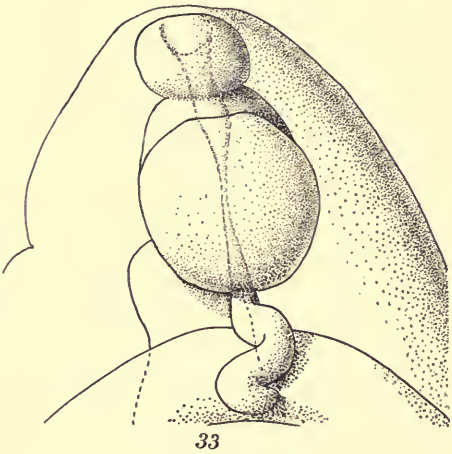

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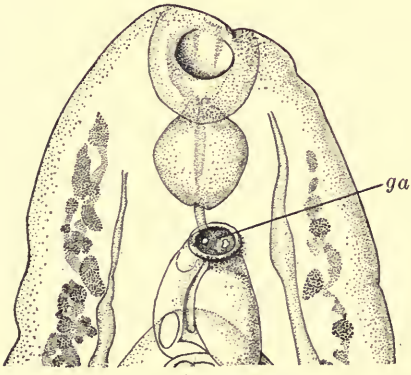

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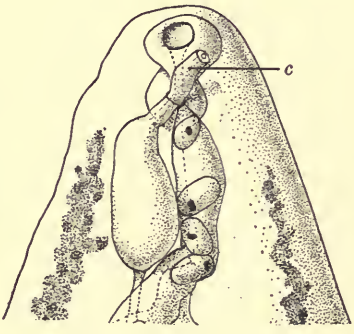

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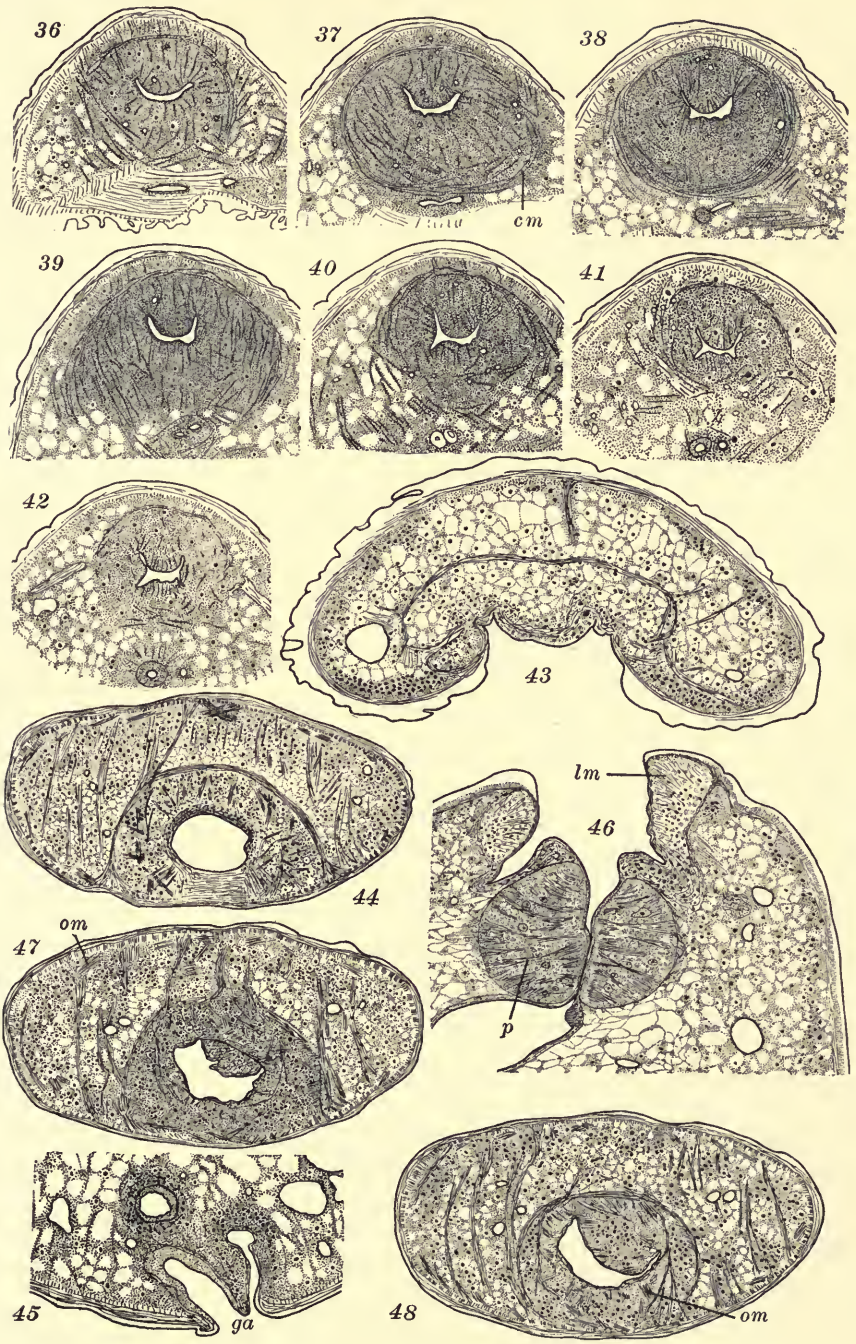
PLATE IX

PLATE IX

Fig.36–42. Inclusive. Consecutive 20 micra sections of oral sucker, *Cyclocoelum halli*. ×71.
Fig. 43. Cross section of oral sucker, *Cyclocoelum pseudomicrostomum*. ×90.
Fig. 44. Cross section through anterior portion of oral sucker, *Cyclocoelum elongatum*. ×90.
Fig. 45. Cross section through genital atrium, *Cyclocoelum elongatum*. ×12.
Fig. 46. Frontal section, *Cyclocoelum elongatum*. ×105.
Figs. 47 & 48. Cross sections of oral sucker of *Cyclocoelum elongatum*, posterior to that in figure 44. ×90.



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